CONSEIL DE LA SCIENCE ET DE LA TECHNOLOGIE

Research and Innovation

Developing a Systematic Priority-setting Process Adapted to Québec's Needs

ADVISORY REPORT

Québec

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Masculine pronouns are used generically in this document to facilitate reading, with no intent to discriminate.

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Édith Deleury
Interim President

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List of Acronyms[1]

ACCORD	Action concertée de coopération régionale de développement (Québec) (Concerted Action for Regional Development Cooperation, Québec)
Acfas	Association francophone pour le savoir (Québec) (French-Language Association for Knowledge, Québec)
ADRIQ	Association de la recherche industrielle du Québec (Québec Association of Industrial Research)
ARC	Australian Research Council
ASRA	Alberta Science and Research Authority
BERD	Business Enterprise Expenditure on Research and Development
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry for Education and Research, Germany)
CFI	Canada Foundation for Innovation
CIRST	Centre interuniversitaire de recherche en science et technologie de l'Université du Québec à Montréal (Interuniversity Research Center for Science and Technology at Université du Québec à Montréal)
CSIRO	Commonwealth Scientific and Industrial Research Organization
CST	Conseil de la science et de la technologie (Québec) (Science and Technology Council, Québec)
DBOS	Databank of Official Statistics, Québec
DSF	Det Strategiske Forskningsråd (Danish Council for Strategic Research)
EFMN	European Foresight Monitoring Network
FQRNT	Fonds québécois de la recherche sur la nature et les technologies (Québec Fund for Nature and Technology Research)
FQRSC	Fonds québécois de la recherche sur la société et la culture (Québec Fund for Research on Society and Culture)
FRSQ	Fonds de la recherche en santé du Québec (Québec Fund for Health Research)
GDP	Gross domestic product
GERD	Gross Domestic Expenditure on Research and Development
HERD	Higher Education Expenditure on Research and Development
ICSTI	Irish Council for Science, Technology, and Innovation
ICSU	International Council for Science
ICT	Information and communication technologies
IPTS	Institute for Prospective Technological Studies (European Union)

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[1] Some titles of french organizations was translated by the author in order to facilitate understanding.

MDEIE	Ministère du Développement économique, de l'Innovation et de l'Exportation (Québec) (Ministry of Economic Development, Innovation, and Export Trade, Québec)
MELS	Ministère de l'Éducation, du Loisir et du Sport (Québec) (Ministry of Education, Leisure, and Sports, Québec)
MINEFI	Ministère de l'Économie, des Finances et de l'Industrie (France) (Ministry of the Economy, Finance, and Industry, France)
MoRST	Ministry of Research, Science, and Technology (New Zealand)
MOST	Ministry of Science and Technology (China)
MSSS	Ministère de la Santé et des Services sociaux (Québec) (Ministry of Health and Social Services, Québec)
NIS	National innovation System
NISTEP	National Institute of Science and Technology Policy (Japan)
NSERC	Natural Sciences and Engineering Research Council of Canada
NSF	National Science Foundation (United States)
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek (The Netherlands Organization for Scientific Research)
OECD	Organization for Economic Cooperation and Development
OST	Office of Science and Technology (United Kingdom)
PCAST	President's Committee of Advisors on Science and Technology (United States)
PREST	Policy Research in Engineering, Science, and Technology, now the Manchester Institute of Innovation Research (United Kingdom)
QRIS	Québec Research and Innovation Strategy
QSIP	Québec Science and Innovation Policy
R&D	Research and development
RSTI	Research, science, technology, and innovation
SME	Small and medium enterprises
SPRU	Science and Technology Policy Research (University of Sussex, United Kingdom)
SSF	Stiftelsen för Strategisk Forskning (Swedish Foundation for Strategic Research)
Tekes	Tekes (Finnish Funding Agency for Technology and Innovation)
UNIDO	United Nations Industrial Development Organization
UQ	Université du Québec (University of Québec)
VRQ	Valorisation-Recherche Québec (Québec Research Transfer Corporation)
VTT	Valtion teknillinen tutkimuskeskus (Technical Research Center of Finland)

Summary of the Advisory Report

The Importance of Priority-setting in Developing Research and Innovation Policies

Québec has a solid national innovation system (NIS) with its own original approach, but one that also takes into account Canadian investment in research and development (R&D). In the past the province's limited resources have forced it to make tough decisions to ensure its social and economic development and position itself as best it could on the national and international stage.

Today the National Innovation System (NIS) is having to rise to new challenges, namely accelerated globalization, increasing competition between developed and emerging countries, and a world economic crisis. As elsewhere, these challenges are obliging public officials to adjust their strategies and rethink some of their ways and methods. Many societies are revisiting the whole issue of governance and turning to the stakeholders to develop effective research and innovation policies. In this regard, ambitious priority-setting exercises would appear crucial to success.

Why Set Priorities?

By definition, a priority is something that receives special attention and that enjoys special treatment in terms of financial resources and other forms of incentive. According to OECD, determining priorities involves explaining and rationalizing choices.

The first stirrings of interest in priority-setting date back to the 1950s in a number of industrialized countries. The implementation of science policies, the acceleration of progress in the fields of science and technology, and the development of social and economic circumstances have for many societies helped make priority-setting a key part of any attempt to build development around innovation.

To the question "Why should we set priorities?" specialists reply:

- Because resources are limited.
- Because in recent years, there has been growing pressure to put science to work to better meet the needs of society.
- Because certain global challenges, be they economic or social, spur societies to become more competitive by adopting strategies that are focused on innovation and the recognition of asset in a few specific areas of advanced knowledge.

Of these challenges, four are particularly indicative of the growing importance of the concept of priority-setting in today's research and innovation policies.

- Globalization.
- Maintenance of a large pool of highly skilled human resources.
- Continued and enhanced development of knowledge and emerging technologies.
- Implementation of new methods of governance.

Priority-setting is not a new phenomenon. For years priorities have been frequently included in research and innovation policies and strategies. What is new is the desire to rationalize approaches and to make them more transparent. In addition, greater participation by various stakeholders in the priority-setting process and improvements to methods have led to positive developments (interaction and discussion of important themes, setting up new contact networks, group reflection, etc.) that are encouraging other societies to take similar action.

To understand the growing importance of priority-setting, it is vital to realize the extent of the changes that both the knowledge society and the new forms of knowledge production it has led to have undergone over the past 20 years. The decisive nature of certain challenges that Québec will have to tackle in years to come should spur authorities to adopt targeted and societal priorities.

These priorities may take many forms. **Functional priorities** are the main objectives an organization or society sets for itself to ensure the operation, development, and enhancement of its research and innovation system. **Thematic priorities** can come in three forms: science priorities, technology priorities, and issue-related priorities. Comprehensive and effective policies and strategies should ideally include a portfolio of priorities that address the need to improve the innovation system, develop scientific and technological knowledge in emerging and high tech fields, and meet the socioeconomic challenges and needs of the country or region.

International Priority-setting Experience

In recent years, an increase has been observed in the number of large-scale priority-setting exercises aimed at developing public policies and strategies for research and innovation. These collective and consensus-building exercises meet the need for a diversified portfolio of priorities and address new imperatives of innovation management (governance, transparency, etc.).

Certain countries have a tradition of priority-setting and world-renowned expertise in this type of exercise, the United Kingdom, Japan, Australia, France, the United States, and Scandinavian countries among them. Others have only recently begun to undertake ambitious priority-setting exercises, but are quickly becoming experts in the field. China, South Korea, and certain countries in South America and the European Union fall into this category.

With a view to producing this advisory report, Conseil de la science et de la technologie (CST) made a list of over 70 priority-setting exercises conducted around the world since the mid-1990s. Closer study of some 20 of them furthered understanding of what such exercises consist of, the thinking behind them, how they were designed, and their possible impacts.

Four broad types of priority-setting exercises for research and innovation were identified:

- "Critical technology" exercises identify current or future technologies that can significantly contribute to a country's economic development. "Technology roadmap" exercises also come under this category.
- "Science research priority" exercises set priorities for major scientific fields or specific research areas, such as neuroscience and aeronautics.
- "Social problem solving" exercises identify socioeconomic challenges or issues that scientific research and development will attempt to address in the coming years. Climate change, sustainable development, and population aging are frequently targeted by this kind of exercise.
- "Mixed" exercises are a combination of two or three of the aforementioned types and aimed at more than one target at a time.

In order to boost the impact of research and innovation priorities selected by priority-setting exercises, a number of organizations have put in place mechanisms for more efficient priority implementation. Budgets are a key tool in this regard and an official means of ensuring sufficient financial resources are allocated to each priority.

Implementing research and innovation priorities usually leads to the creation of programs, organizations, research groups, research institutes, research chairs, strategic grants, or umbrella programs that are often multidisciplinary and that involve large numbers of researchers.

In addition to studying the impact of priorities on research organization, experts are taking a growing interest in the social effects of priority-setting exercises on all stakeholders in the innovation system. Mobilizing stakeholders and creating opportunities for group contact and discussions are among the most sought-after positive effects.

Ten Observations Drawn From International Experience

The various experiences studied in this advisory report have provided greater insight on the way priority-setting exercises are designed and conducted around the world. Ten observations can be drawn from this work.

1) The priority-setting exercises conducted in the last 15 years have been an opportunity to experiment with new methods and approaches.
2) As a general rule, priority-setting exercises begin as political initiatives, but are run by various bodies.
3) Priority-setting exercises generally involve numerous stakeholders from an increasingly wide range of backgrounds.
4) The greater the importance political leaders publicly accord the priority-setting process, the greater its odds of success.
5) Major priority-setting exercises tend to take quite specific approaches that draw on a variety of methods but follow a relatively similar logic.
6) Exercises often identify priorities on a medium and long-term time perspective, which makes foresight a growing concern in priority-setting.
7) Priority-selection criteria are usually based on the notions of attractiveness and feasibility.
8) The seeming convergence of national thematic priorities around the world does not rule out a higher level of diversity within each country.
9) The impact a priority-setting exercise has is contingent not only on the results it yields (list of priorities), but particularly on the manner in which the priority-setting process is designed and carried out as a whole.
10) Evaluating priority-setting exercises helps provide a better understanding of the tangible and intangible impacts of the exercise, while improving the priority-setting practices of a society or organization.

Prerequisites to Successful Priority-setting

Priority-setting is a complex activity that requires familiarity with its practical and theoretical intricacies in order to ensure success. It must be based on the collective reflection of concerned and committed stakeholders and must be directed by a group that can lend it the legitimacy needed to create an impact.

Six prerequisites to successful priority-setting are identifiable from international experiences:

1) Recognize the need to set priorities.
2) Secure government support.
3) Stress rigor and transparency.
4) Keep the lines of communication open for the duration of the exercise.
5) Conduct the exercise in an international perspective.
6) Put in place a realistic management framework to see the project through.

Setting Research and Innovation Priorities in Québec

A cursory glance at how science policies and research and innovation strategies have developed in Québec shows that most address the issue of priorities. From the 1970s onward, there has been a general recognition of the need to set priorities, and answers have been sought on how best to do so.

The Québec government has often chosen to invest in science or technology in tandem with Canada, thereby giving the province's researchers an advantage in obtaining federal funding. Québec has also put programs in place to increase more strategic research into key themes. Focusing on a few priority sectors has given the government international clout and created a lever effect to draw investment to Québec from elsewhere in Canada and abroad. In addition, Québec has also always sought to encourage stakeholder involvement and multidisciplinary research.

Little by little Québec has therefore adopted an original and creative approach that has enabled various stakeholders to experiment with new priority-setting methods for research and innovation. For instance, from 1999 to 2006 Valorisation-Recherche Québec (VRQ) developed Québec's strategic investment capacity for research, particularly through ambitious projects in key sectors. Fonds québécois de la recherche sur la nature et les technologies (FQRNT), Université du Québec, and ministère du Développement économique, de l'Innovation et de l'Exportation have also experienced new priority-setting processes.

Since 2003, CST's Science, Technology, and Society Perspectives project has brought knowledge producers and users together to determine priority challenges and direct part of the research and innovation effort toward selected social issues.

Six Findings

Six findings that arise from the Québec experience should be considered when developing a priority-setting approach for the province.

1) Québec has set research and innovation priorities for at least three decades. Although primarily functional in nature, they have been complemented more recently by thematic or sectoral priorities. Yet functional priorities still predominate to this day.
2) The importance and necessity of setting priorities has been stressed many times in research and innovation policy and strategy documents.
3) The constitutional context, marked by the predominance of federal public funding of R&D, has motivated Québec to position itself strategically using a creative and innovative approach to the way it funds and sets its priorities for R&D.
4) There is relatively broad consensus in Québec with regard to certain key sectors or cutting edge technologies (ICT, biotechnologies, nanotechnologies, aerospace, pharmaceuticals, etc.).
5) Regardless of type of priority, the priority-setting process has not been clearly defined up till now. Nor has it looked to the medium and long-term (foresight exercises have been rarely used).
6) In recent years there has been renewed interest, both in Canada and Québec, in priority-setting issues and objectives, as well as in methods of improving the process of setting research and innovation priorities.

Gains for the Québec Research and Innovation Strategy

To face the modern-day challenges of globalization, we need to reexamine how we do things. The Québec government already invests extensively in research and innovation, and its innovation system has a strong track record. However, to maximize the benefits of these investments in a context of growing international competition, Québec has no choice: it must mobilize and involve all concerned stakeholders. Updating the Québec Research and Innovation Strategy (QRIS) provides an opportunity to do just that.

In addition to setting functional and thematic priorities for research and innovation, priority-setting in Québec should aim to:

- Bring stakeholders together.
- Provide Québec with strategic intelligence that is shared among concerned stakeholders.
- Pursue the development of world-class strategic research resources so as to be able to take advantage of opportunities here in Canada and abroad.
- Formulate an original and creative approach that enables Québec to stand out and put forward its own priorities.
- Allow public bodies to support research and innovation in accordance with key, jointly defined strategic priorities.

In order to meet these objectives, CST has formulated three main recommendations.

Recommendation 1

That ministère du Développement économique, de l'Innovation et de l'Exportation adopt a more systematic, rigorous, and transparent priority-setting process to help draft future Québec research and innovation policies and strategies.

Systematizing the priority-setting process involves:

- Developing a set of practices and methods specifically designed to identify priorities for research and innovation.
- Designing a recurrent approach.
- Improving coordination of priority-setting initiatives by involving a strategic core of concerned stakeholders partially or wholly dedicated to this task.

To fulfill these three conditions, it is important to take into account five specific requirements:

- Implementation of the priority-setting process for research and innovation should be inspired by factors that contributed to the success of major priority-setting exercises elsewhere in the world.
- The priority-setting strategy should be designed to take into account Québec's specific characteristics:
    - A national innovation system that brings together a variety of stakeholders.
    - The significant federal government contribution to public funding for research in Québec.
    - A tendency to form strategic groups focused on major research themes.

- The priority-setting strategy should be based on principles of governance in order to maximize participation and stimulate involvement in the exercise.
- All exercises in priority-setting for research and innovation should be part of an effective strategic watch system that meets the highest international standards.
- Responsibility for conducting exercises to identify research and innovation priorities should be entrusted to a group or body capable of securing broad stakeholder involvement and support.

Recommendation 2

That ministère du Développement économique, de l'Innovation et de l'Exportation, in conjunction with its partners, develop a portfolio of functional and thematic priorities that are adapted and flexible in order to meet the immediate and future needs of Québec's national innovation system stakeholders and the population.

Diversifying priorities enhances the effectiveness of action throughout the innovation system. Priority-setting strategies must allow for the establishment of priorities that are limited in number, but of different types, both functional and thematic. Since each type of priority is a response to specific imperatives, this diversity must also be reflected in the very concept of thematic priorities. This can be achieved by opting for issue-related priorities that also incorporate a technological or scientific component. The same goes for functional priorities, which must simultaneously allow for action within the two main components of the national innovation system-the research component and the innovation component.

Recommendation 3

That ministère du Développement économique, de l'Innovation et de l'Exportation continue to maintain a solid and comprehensive research base and provide support for the various phases of the innovation process.

Since Québec barely produces 1% of the world's knowledge, it is critical that it rise to the challenge of mastering scientific knowledge produced in other countries. For this reason, it is not only important to focus on certain key sectors, but also to:

- Maintain a high level of basic scientific knowledge acquisition in Québec universities and research centers.
- Have access to a sufficient pool of researchers in all possible fields, both in science and engineering and in the social sciences and humanities.
- Train a qualified workforce to serve as the driving force for innovation in the future.

Knowledge building, consistent support for the various phases of the innovation process, and skilled workforce training are tried and tested ways to react to unanticipated changes.

Conclusion

Implementing a systematic priority-setting process that is adapted to Québec will provide the tools for greater strategic intelligence to be shared among stakeholders. This will help Québec weather economic storms and ensure the long-term development and well-being of those who live there.

Introduction

In its 2006 brief on updating the Québec Science and Innovation Policy, CST began by pointing to the progress that had been made in the previous 40 years on developing Québec's innovation system. "Québec has a number of aces up its sleeve for boosting economic and social activity, among them an impressive public and private labor force in research and innovation, a pool of top-caliber researchers and research units, a province-wide network of universities and colleges, numerous liaison and transfer mechanisms, and a diversified network of scientific organizations.[2]"

Québec has a solid national innovation system (NIS) with its own original approach, but one that also takes into account Canadian investment in research and development (R&D). In the past the province's limited resources have forced it to make tough decisions to ensure its social and economic development and position itself as best it could on the national and international stage. This has led many Québec research and innovation stakeholders to come up with original ways to set priorities to meet their own needs.

Today Québec's national innovation system is facing new challenges, namely accelerated globalization, increasing competition between developed and emerging countries, and a world economic crisis. As elsewhere, these challenges are obliging public officials to adjust their strategies and rethink some of their ways and methods. Many societies are revisiting the whole issue of governance and turning to the stakeholders to develop effective research and innovation policies. In this regard, ambitious priority-setting exercises would appear crucial to success.

As the government is preparing to update the Québec Research and Innovation Strategy (QRIS), CST has decided to again contribute to the general discussion by looking at priority-setting from the angle of tried and tested processes elsewhere in the world.

This advisory report is also a response to the fifth challenge set out in Phase I of the STS Perspectives (Science, Technology, and Society Perspectives) project "target strategic and priority market niches in the areas of research, economic development, and education, based on current strengths and emerging sectors." This foresight project, which is based on consultation with the public and the scientific community, led to the drawing up of seven major challenges facing Québec, challenges to which science and technology could make a significant contribution over the next 20 years.[3] Phase II of the project, which has been ongoing since 2005, involves coming up with research strategies to meet the challenges identified in Phase I. The particular nature of the fifth challenge, along with the growing need to set priorities when developing research and innovation policies, persuaded CST to address the challenge and present an advisory report on it to the Québec minister responsible for research and innovation.

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[2] Conseil de la science et de la technologie (2006), *La mise à jour de la Politique québécoise de la science et de l'innovation. Mémoire présenté au ministre du Développement économique, de l'Innovation et de l'Exportation*, (Update to the Québec Science and Innovation Policy. Brief Presented to the Minister of Economic Development, Innovation and Export Trade), p. 3, http://www.cst.gouv.qc.ca/Memoire-sur-la-mise-a-jour-de-la.

[3] For more information about the STS Perspectives project, visit http://www.cst.gouv.qc.ca/LE-PROJET-PERSPECTIVES-Science,384.

This report does not aim to set any priorities. Instead it seeks to update knowledge of priority-setting processes and report on exemplary practices that Québec could draw on to improve its methods. Five chapters will explore various facets of priority-setting.

- Chapter 1 provides a better understanding of what priority-setting entails and outlines its importance and usefulness in developing research and innovation policies today.
- Chapter 2 takes stock of priority-setting experiences from around the world that experts consider to be exemplary and innovative.
- Chapter 3 sets out ten observations on the priority-setting process and certain conditions required to ensure such an exercise succeeds.
- Chapter 4 deals more specifically with the priority-setting situation in Québec (the link between scientific policy and priority-setting, the impact of the federal government on Québec's research and innovation priorities, and strategic actions taken by some national innovation system stakeholders).
- Chapter 5 reiterates the report's key points and formulates three recommendations for a more rigorous, systematic, and explicit priority-setting process in Québec.

The advisory report is an incentive for the government to follow the latest trends as it seeks to bolster Québec's strategic intelligence capabilities. It is also a contribution to the general debate on priority-setting, which began with Québec's first science policies and could benefit from the input and insights of other national innovation system stakeholders over the next few years.

Chapter 1
The Growing Importance of Priority-setting in the Drafting of Innovation Policies

1.1 Priority-setting to Address Today's Socioeconomic Issues

In recent years, more and more countries have been targeting strategic research fields on which to focus their R&D efforts. At the same time, more and more governments are setting core national objectives, entrenched in their research and innovation policies, that aim to enhance the efficacy of their national and regional innovation systems. These priorities are having a considerable impact on the organization and public management of research.

While priority-setting has become a particular focus of attention worldwide, neither the way in which priorities are set, the justification for them, nor the end results they generate have received much attention, even though they are sometimes controversial. Yet there has been no shortage of priority-setting experiences in Québec and around the globe, and analyzing them can help demystify the process by shedding light on its benefits and essential nature, especially given the current context.

This context is characterized by a number of transformations, both in relation to the way science and innovation policies are drawn up and in terms of research systems and knowledge production. The growing importance of priority-setting–a phenomenon that has accelerated in recent years–can be explained by various factors, but mostly by the social changes that have marked the past fifty years:

- **The knowledge society and the dynamics of the knowledge economy** have made knowledge a strategic concern in which more targeted investment must be made in order to stand apart and stay competitive on the international scene.
- **New knowledge production methods (the transformation of worldwide research systems)** are characterized by greater commercialization of research, the accountability of science, and multidisciplinary or interdisciplinary collaboration, all of which foster specialization of part of the research produced.

Sidebar 1 – Common Features of New Knowledge Societies[4]

- Accelerated technological change on a global magnitude.
- An increasingly systemic and relational dynamic strongly focused on developing networks.
- Special emphasis on lifelong learning.
- Ever-greater mobility of science and technology workforce due to globalization and the permeability of borders.
- The explosion in means of communication and rapid growth in all forms of interaction.
- Greater emphasis on certain values such as creativity and entrepreneurship and special attention to matters of ethics.
- An increase in R&D spending as well as continued efforts to stimulate innovation and research.

These changes in the knowledge society and knowledge production have given rise to new challenges in Québec and many countries around the world. Some of the changes have created a growing interest in priority-setting in research and innovation. To the question "Why should we set priorities?" the main references consulted reply[5]:

1) Because resources are limited.

The need to set priorities is immediately apparent at a time when the resources provided to the public research system are limited. This is especially problematic in smaller societies such as Québec. Governments often opt to concentrate their efforts in a few strategic areas rather than spread their limited resources too thinly across numerous fields of research.

2) Because in recent years, there has been growing pressure to put science to work to meet the needs of society.

Some needs voiced by the public require the development of new knowledge. The production of knowledge in response to social demand is one form of determining priorities. Research that is directed in this way aims to maximize part of the public investment, and the methods used to define this social demand require new governance practices.

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[4] For more on the knowledge society, see works by UNESCO, OECD, Helga Nowotny, and Michael Gibbons, among others.

[5] See the brief *Vers un processus de priorisation systématique et adapté pour le Québec - Bibliographie* (A Systematic Priority-setting Process for Québec - Bibliography) available in French at http://www.cst.gouv.qc.ca/-fr-.

3) Because certain global challenges, be they economic or social, spur societies to become more competitive by adopting strategies that are more often focused on innovation and the international recognition of prowess in a few specific areas of advanced knowledge.

Of these challenges, four are particularly indicative of the growing importance of the concept of priority-setting in today's research and innovation policies. They include 1) globalization, 2) maintaining a critical mass of highly qualified human resources, 3) implementing new methods of governance, and 4) the continued and enhanced development of knowledge and emerging technologies in a more long-term perspective.

1.1.1 Globalization is Accentuating the Popularity of Priority-setting.

Globalization is characterized in part by "the continued and accelerated growth in economic activity on the international scene."[6] Globalization, combined with the burgeoning growth of BRIC[7] countries, has been the catalyst for the strategic repositioning of Western countries with modern, developed economies.

The inclusion of companies and multinationals in the global value chain fragments production throughout different countries and forces local companies to specialize in certain fields where their region has its own unique strengths (availability of a qualified workforce, access to a pool of researchers, developed technology clusters, and others). This repositioning calls for increased investment in new sectors-often those with a focus on high tech and advanced knowledge.

Research and innovation are costly and require considerable resources. The choice of strategic sectors is therefore crucial. In its 2008 Situation Report, CST states that "Québec must accurately assess its potential and its strengths and weaknesses, as well as identify the most critical issues it must focus on and the advantages it must leverage in order to grow."[8] This is a huge challenge that requires strategic intelligence as a means to counter the effects of globalization.

Many countries that have noted this challenge have recently implemented research and innovation policies and strategies that incorporate priority-setting exercises as a way to identify fields where they have the upper hand and can use this to remain competitive globally. For example, in 2006 the Danish Government published its strategy *Denmark in the Global*

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[6] Conseil de la science et de la technologie (2008), *Innovation et mondialisation. Rapport de conjoncture 2008*, p. 3, http://www.cst.gouv.qc.ca/Innovation-et-mondialisation. (Innovation and Globalization, 2008 Summary of the Situation Report, http://www.cst.gouv.qc.ca/IMG/pdf/Summary_RC_2008_Innovation_et_Globalization_2008-05-30_.pdf).

[7] The acronym BRIC refers to Brazil, Russia, India, and China.

[8] Conseil de la science et de la technologie (2008), *op. cit.*, p. 6.

Economy[9] that included the focus area *More competition and better quality public sector research*. For this area, it outlined initiatives to step up strategic research in the country while improving priority-setting processes that help in the identification of research themes.

Another impact of globalization has been the increasingly international face of R&D. This phenomenon is primarily characterized by the speed at which scientific and technical information circulates and by the jump in the number of countries involved in the production of knowledge and in technological development.

The latest statistics show that in 2005, Québec produced approximately 1.1% of worldwide scientific literature in science and engineering, most of it by the university sector (85.9%)[10]. While there are no exact figures for the social sciences, we can conclude that Québec's contribution to the production of global knowledge is still modest. This observation raises two key issues:

1) The absorption of the 99% of knowledge produced elsewhere in the world.
2) The importance of identifying our fields of expertise and scientific strengths (knowledge mapping)[11].

Numerous organizations are implementing collaborative programs aimed not only at boosting the participation of their researchers in major international research projects, but also at further stimulating the creation of worldwide knowledge production networks. And indeed, there has been an increase in research partnerships over the years. Major scientific projects are increasingly defined along lines of specific themes with a multidisciplinary aspect and operate more often than not on two levels:

1) Contributing to the development of knowledge in high tech sectors that have been singled out by authorities in various countries for their promise.
2) Contributing to research with a social purpose aimed at resolving major global problems such as climate change.

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[9] Government of Denmark (2006), *Progress, Innovation and Cohesion. Strategy for Denmark in the Global Economy*, p. 25, http://www.globalisering.dk/multimedia/Pixi_UK_web_endelig1.pdf.

[10] Institut de la statistique du Québec (2007), *Compendium d'indicateurs de l'activité scientifique et technologique au Québec*, (Compendium of Science and Technology Activity Indicators in Québec) p. 211, http://www.stat.gouv.qc.ca/publications/savoir/compendium2007_pdf.htm.

[11] As explored from the angle of the production of scientific articles by the group Science-Metrix on behalf of CST.

In both cases, the decision to invest financial and human resources in such international research projects is a result of the prior selection, formal or otherwise, of themes deemed a priority and in which it is essential to invest for the well-being of the population.

1.1.2 Québec's Attractiveness in Several High Tech Fields is Further Enhanced by its Skilled Human Resources Specialized in Certain Strategic Sectors.

The requirements of the knowledge economy impact the entire innovation system. Since the economic growth of countries is increasingly dependent on innovation, it is critical to foster the training of qualified human resources, the people who produce and disseminate knowledge nationally and internationally.

In order to enhance their attractiveness worldwide, cities, regions, and countries are seeking ways to maximize the skills of their workforce and attract foreign R&D investment. One result of this trend, which is discussed in *OECD Science, Technology and Industry Outlook 2008*[12], is that higher education plays a pivotal role in new science, technology, and innovation strategies.

Since knowledge circulates in large part through the international mobility of researchers, it is imperative to design measures and tools not only to retain Québec's workforce but also to attract new researchers from abroad. One undeniable source of attraction is to define ourselves as a research powerhouse in a given scientific field. Priority-setting, which is a way to target some of the investments and research initiatives in key sectors, offers the advantage of developing internationally recognized strengths in these areas as well as modern facilities that meet the requirements of the world's leading researchers. Concentrating part of our R&D efforts in specific fields could also help spur young international talents to opt for Québec rather than the United States or Europe, even though ours is a small economy.

Being strong in certain priority research sectors does not render all other forms of research in basic disciplines of any less value. On the contrary, in many OECD countries the figures point to a sustained and even growing interest in highly skilled workers in fields such as chemistry, physics, mathematics, and social sciences. The term "knowledge economy" implies the constant and continued development of knowledge and of international talent in a vast array of fields. To stay competitive, societies must not only possess strengths in certain fields, they must also have a very broad grounding in basic fields of knowledge that underpin many of the greatest discoveries.

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[12] OECD (2008), *Science, Technology and Industry Outlook 2008*, Paris, OECD, http://www.oecd.org/document/41/0,3343,en_2649_34273_41546660_1_1_1_1,00.html.

This is why some priority-setting exercises include a basic research component, as is the case in a number of European countries, at European Commission, and in American organizations such as National Science Foundation (NSF). The development of highly qualified workers is also a key functional priority in many policies and strategies.

1.1.3 Determining Promising Technologies and Emerging Research Fields is Strategic to a Country's Economic Development.

In recent years there has been a trend toward increased public spending on R&D, despite the recent slowdown in industrial R&D spending in a number of countries. It is driven by several factors, including the "race" to spend 3% of gross domestic product (GDP) on R&D–a target set by a number of European and other countries. The decision to invest in knowledge is a sign of the transformation of our economies, since to stay competitive in a knowledge society, it is important to

- *Promote research and development by ensuring the consistency of initiatives all along the innovation chain.*

  To ensure their survival in this age of globalization, societies must be able to transform their bank of innovation knowledge into wealth and well-being for their citizens. That is why priority-setting exercises must take into consideration every aspect of the innovation system and help define not only research priorities, but also innovation priorities.

- *Quickly and effectively identify promising technologies and emerging fields of research with strategic and profit-making potential on the world market.*

  The document *OECD Science, Technology and Industry Outlook 2006*[13] states that "[...] countries continue to develop technology foresight initiatives to identify challenges and respond to opportunities in new and emerging science and technologies. These efforts help identify areas of research priority. Finland, New Zealand, Korea, Italy, Iceland, and the United Kingdom have new foresight initiatives" (2006, p. 50). Exploring new knowledge and the social demand that stimulates scientific development is now considered essential in implementing policies and determining research and innovation priorities.

More recently, OECD[14] has noted a trend in various countries toward mid to long-term national strategies or policies, some of which extend far beyond the political terms of current governments. Adopting a long-term vision requires mechanisms that enable us to 1) gain a better understanding of the existing national innovation system, 2) effectively pinpoint any changes in the national innovation system, and 3) explore the opportunities for scientific and technological development. These three requirements represent a significant challenge for every country and organization since they call for foresight and monitoring tools as well as a major change in the culture of organizations tasked with drawing up science and innovation policies.

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[13] OECD (2006), *Science, Technology and Industry Outlook 2006*, Paris, OECD, http://www.oecd.org/document/61/0,3343,en_2649_34273_37675902_1_1_1_1,00.html.

[14] OECD (2008), *Science, Technology and Industry Outlook 2008*, Paris, OECD, http://www.oecd.org/document/36/0,3343,en_2649_34273_41546660_1_1_1_1,00.html.

1.1.4 New Methods of Social Governance Spur the Democratization of Priority-setting Processes.

The concept of governance took hold gradually in the 1990s. It calls, among other things, for greater involvement by the public and by knowledge producers in decision-making and the drafting of public policies. The role of the state has moved away from the traditional hierarchical management mode to a network-based management mode that revolves more around coordination, polycentrism, and consensus building.

In recent years, the prevalent concern about accountability[15] has also affected the way research is governed. Ever-broader public involvement in decision-making processes requires public research to be more transparent than ever and to be accountable for results. According to OECD, “in the governance of science systems and the allocation of public research funding, governments are therefore led to demand results while keeping an eye on the equilibrium and future of the science system.”[16]

In its most recent Situation Report[17], CST reiterates three main ideas on governance:

1) It is possible to provide good overall management of the system to optimize its general operation and performance.
2) The state is not the only actor. It must share responsibility with other stakeholders to ensure the system is managed in a coordinated manner.
3) We must strive to bring everybody on board if we can around a handful of key development objectives on which consensus has been reached.

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[15] Mulgan (2000, p. 555) and Engstrom and Leon (1996, p. 333) define accountability as the process by which a responsible person must explain and justify his or her decisions and actions to an institutional authority (or hierarchical superior) while demonstrating effective and efficient use of resources.

[16] OECD (2003), *Science and Innovation Policy: Key Challenges and Opportunities*, Paris, OECD.

[17] Conseil de la science et de la technologie (2008), *op. cit.*, p. 138.

These ideas represent challenges, and they have an impact on the traditional priority-setting processes. As this advisory report will demonstrate in the following chapters, priority-setting exercises in recent years have tended to become more democratic as they have called on a growing number of stakeholders. The widening of this process appears to have led to a significant improvement in the implementation of priorities while building consensus around the research themes deemed important for future economic development.

Today's new socioeconomic challenges go a long way to explaining the growing importance of priority-setting in drafting innovation and research policies. But the importance of priority-setting today is also a result of its development over the years, which has changed the way we determine our priorities and, by the same token, the very essence of priority-setting in public research management.

1.2 Main Theoretical Concepts and Definitions

1.2.1 What is a Priority?

By definition, a priority is something that receives special attention and that enjoys special treatment in terms of financial resources and other forms of incentive.[18] The concept of "choice" is closely linked to that of "priorities." According to OECD, determining priorities involves explaining and rationalizing choices.[19]

Long the exclusive domain of senior decision makers, priorities are still often defined by a handful of individuals aided by their knowledge of the situation at hand and a small circle of experts. However, there is a growing trend toward large-scale priority-setting exercises designed to involve a greater number of stakeholders in determining research and innovation spending priorities. Priorities are set using a structured approach of sustained reflection drawing on input from experts (researchers or practitioners). These priority-setting experiences generally take several months and tend to include consultations with various groups of stakeholders.

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[18] OECD (1991), *Choosing Priorities in Science and Technology*, Paris, OECD.

[19] Ibid.

1.2.2 Background

The first stirrings of interest in priority-setting date back to the 1950s in a number of industrialized countries in response to scientific advances and the development of research and innovation investment policies. In her PhD thesis published in 2003, Heide Hackmann[20] looks at the history of priority-setting, dividing it into four key periods:

The Building Blocks of Priority-setting	
From 1940 to the late 1950s	• Introduction of the first science policies • Researcher freedom: "science push" model • Emphasis on specific research themes

In 1945, Vannevar Bush, an American engineer and advisor to F.D. Roosevelt, published a report that created a huge impact on the way scientific activity was perceived and managed. The author was the first to associate scientific progress with achieving a certain ideal in health, prosperity, and security. This progress, according to Bush, hinged on the support governments provide to research and on preserving the total freedom of researchers, who, driven by curiosity, explored the unknown. According to OECD[21], Bush's thesis was based on the idea that the practical applications of scientific research were an inescapable but unpredictable consequence of what was then termed "basic" research.

Researcher freedom therefore, in principle, implied no defined research priority. However, R&D funding was usually sectoral (especially in the United States and Europe), with special emphasis on three specific fields: the military, atomic energy, and health research. Hackmann noted that these were national priorities, since applied research institutes and establishments were created specifically to support scientific discoveries in these areas. Sector-specific agencies such as Office of Naval Research, Atomic Energy Commission, and National Institutes of Health were created in the U.S. Other sectoral research organizations were also founded in Europe, notably in France and the Netherlands, creating a distinction between basic and applied research, since the latter was associated with the thematic priorities of governments and their departments.

In 1957, the Russians launched their *Sputnik program*, signaling a growing interest in aerospace and triggering a global race for discovery and progress. The program led to a huge jump in investment in science and technology as countries competed to outdo the Russians. In turn, this increase in spending gave rise to the development of European and American science policies.

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[20] H. Hackmann (2003), *National Priority-Setting and the Governance of Science. Dissertation*, Netherlands, University of Twente.

[21] OECD (1991), *op. cit.*, p. 14.

First Methodological Questions About Priority-setting	
1960s	• Science policies • Concerns about how to make choices • Importance of scientific freedom

The increased spending in science and technology drew the attention of a number of intellectuals at the time, sparking a debate on how to allocate research funding and turning the concern into a political issue.

In 1963 American physicist Alvin M. Weinberg published an article entitled *Criteria for Scientific Choice*, which sought to answer the question "How should priorities be set?" He identified two sets of criteria: 1) internal criteria to answer the question *How well is the science done?* and 2) external criteria that answer the question *Why pursue this particular science?*[22] The article met with critical acclaim, inspiring a number of organizations to prioritize or evaluate certain research fields, among them the National Academy of Sciences, which used the Weinberg criteria in 1972 in a priority-setting exercise aimed at identifying areas of physics specialization, e.g. nuclear physics.[23]

However, these reflections and debates on priority-setting had little influence on the traditional ways of conducting research (divided along disciplinary lines) and didn't change the way the principle of scientific autonomy was applied.

Surge in Core Priorities and the Processes Used to Determine Them	
1970s and 1980s	• Technological policies • Priority generic technologies • introduction of the concept of strategic research

In the early 1970s, priority-setting was still a concern for science ministries, agencies and organizations. Priorities were regularly set by politicians and decision makers using a "top down" approach and implemented via major national research programs. These thematic programs had proliferated since the 1960s, and priority-setting was a sign of the willingness to change the way science was managed.

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[22] This duality still exists regarding quality criteria and relevance criteria.

[23] The report *Physics in Perspective* subsequently inspired similar exercises in other countries.

In 1971, OECD publication *Science, Growth and Society: A New Perspective*[24]—better known as the Brooks Report—had a significant impact on the way scientific development was perceived. It noted, among other things, that science and technology were an integral part of economic and social development, and this called for a much closer relationship than in the past between science and technology policies and all areas of socioeconomic concern and government responsibility.[25]

This report noted that prior to 1970, science policy priorities and choices were determined by external pressures such as national defense, considerations of prestige, or competition from world markets. The public's new questioning of the potentially harmful effects of science spurred authorities to shift certain research themes from an essentially economic or military slant to more social applications. Major priority health programs were introduced, such as programs to fight cancer, and there was increasing concern for the environment.

In the 1980s burgeoning economic growth in many Asian countries led to other changes that would impact priority-setting. In order to remain competitive, a number of Western countries revised their strategies, making advanced generic technologies their new priority fields (biotechnology, industrial materials, microelectronics, information and communication technologies [ICT], and, later, nanotechnology).

Decision makers wanted to ensure that major research programs would boost the innovation potential of the various high tech sectors. It was at this time that Irvine and Martin introduced the concept of "strategic research," which they define as follows:

> *Strategic research is basic research carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognized current or future practical problems.*[26]

This idea of strategic research became a key focus of the actions of a number of countries renowned for the efficiency of their national innovation systems. This was in large part because it proposed a new approach to the funding and organization of research based on its capacity to respond to contemporary socioeconomic challenges while contributing to the development of a strategic and collective vision shared by all its stakeholders. In this respect, strategic research:

- Takes into account society's needs in the very definition of research priorities (change in priority-setting processes).
- Is multidisciplinary and focused on solving today's main social problems.

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[24] OECD (1971), *Science, Growth and Society: A New Perspective. Report by the Secretary General's special group on new concepts in science policies*. In R. Pitre (1994), *La culture scientifique et technique et les politiques scientifiques au Québec: le rôle de l'OCDE* (Scientific and Technical Knowledge and Science Policies in Québec: The Role of OECD), http://www.cirst.uqam.ca/PCST3/PDF/Communications/PITRE.PDF.

[25] OECD (1971), *op. cit.*, p. 107.

[26] J. Irvine and B.R. Martin (1984), *Foresight in Science. Picking the Winners*, London, Frances Pinter.

- Contributes to the research base of new scientific know-how and, at the same time, enhances knowledge in specific fields of research.
- Is backed and legitimized by political authorities and made a part of the government's strategies and action plans.
- Is complementary to other types of research (industrial, basic, etc.) that are driven by individual initiative as opposed to societal demand.

From that point on, the traditional dichotomic conceptions of research gave way to new conceptual categories in which priority-setting was no longer either systematically associated with applied research or contrasted with free or fundamental research.

Sidebar 2 – How the Concept of Strategic Research is Used in Scandinavia and Elsewhere

A number of recent examples point to the continued importance of the concept of "strategic research" and reflect a trend towards a democratization of the term.

For Denmark's Ministry of Research, Technology, and Innovation, strategic research is seen primarily as a driver of economic growth, one that helps provide solutions to significant social problems. It may be either basic or applied research, but it must reflect societal priorities and be approved and supported by the Danish parliament. This notion of strategic research is central to the ministry's most recent strategy entitled *Research 2015. A Basis for Prioritization of Strategic Research*, which was released in 2008.

Denmark wasn't the first country to apply this concept. It was inspired by other countries to reorganize its advisory system by emphasizing the distinction between "strategic research" and "independent research." Swedish Foundation for Strategic Research (Stiftelsen för Strategisk Forskning - SSF), founded in 1994, was one of the first organizations to use the term "strategic research." It distributes over 6 million Swedish kroner (about CAN$1 million) a year for research projects that meet the highest international standards and help boost the country's competitiveness.

In June 2006 in Finland, in the wake of recommendations by Council for Scientific and Technological Policy (Tiede- ja teknologianeuvosto), the Finnish Academy (Suomen Akatemia) and the Finnish Funding Agency for Technology and Innovation (Tekesin - Tekes) undertook to create strategic centers for science, technology, and innovation in fields deemed key to Finnish society, business, and industry. To date, five such strategic research centers have been created in five fields pegged as priorities by the Finns (energy and the environment, metals and mechanical engineering, forestry, health and welfare, and the ICT industry).

Other examples of strategic research include the strategic research fund administered by the Dutch Organization for Scientific Research (Nederlandse Organisatie voor Wetenschappelijk Onderzoek - NWO) and Singapore's recently created NRF Strategic Research Programs.

In the European Commission's *European Innovation Progress Report 2008* published in January 2009, the creation of long-term strategic research policies is the second most common research and innovation measure among the 27 member states of European Union (17% of a total of 1,157 measures).[27]

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[27] European Commission (2009), *European Innovation Progress Report 2008*. Brussels, European Commission, http://www.proinno-europe.eu/admin/uploaded_documents/EIRP2008_Final_merged.pdf.

Globalization Sparks a Rise in the Popularity of Priority-setting	
1990s to today...	• Innovation policies • Major priority-setting exercises • Improvements to priority-setting methods and approaches

The 1990s were marked by greater financial constraints and a certain stabilization, even a drop in some cases, of R&D spending in industrialized countries. However, science and technology played an important strategic role in helping countries remain economically competitive on global markets. Growing public concern about science led to notable changes in the way public policies were drawn up. Science and innovation research governance and decision-making became ever more complex.

In the wake of these changes, countries increasingly turned to priority-setting, and determining these priorities became essential to the management of R&D funding.

It was in the 1990s that a number of major priority-setting exercises were carried out in Europe, Asia, and North America. These experiences involved a large number of stakeholders, primarily from the scientific community and government. In 1990, OECD released one of the first studies on priority-setting processes around the world. *Choosing Priorities in Science and Technology*[28] looks at the priority-setting processes used in OECD member countries at the time. The widely cited document has been vital to the advancement of knowledge in this field.

During the 1990s, countries experimented with a whole host of methods to define priorities in a more rigorous and consensualist manner. Foresight became an increasingly important part of priority-setting exercises, and the social value of research now carried equal weight to the economic value. Research had to be socioeconomically relevant in order to create wealth and ensure the well-being of the population.

With the dawn of the third millennium came new challenges that further boosted spending in R&D to help countries remain competitive on the world economic stage. Now more useful than ever, priority-setting became a strategy virtually every country turned to on occasion, as we will see in the following chapters.

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[28] OECD (1991), *op. cit.*

1.2.3 Two Main Types of Priorities

This advisory report look at the history of priority-setting provides insight into the continued interest in the issue since the middle of the 20th century, an interest that has fostered the development of knowledge in this field through the contribution of numerous researchers and organizations. Research and studies on priority-setting have helped bring to light two main categories of priorities–thematic and functional.[29]

Functional priorities are the main objectives an organization or society sets for itself to ensure the operation, development, and enhancement of its research and innovation system. They help improve the way research is conducted and ensure the innovation system operates as effectively as possible. These priorities apply not only to existing structures, but also to the way scientific and technological activities are carried out and evaluated.

Thematic priorities are disciplines, sectors, areas of research, or specific technologies that are singled out to receive greater resources and investment than others. These themes are selected according to certain criteria and are deemed crucial to the social and economic development of society or research organizations or institutions. They may be more traditional fields of research such as chemistry or physics, or emerging disciplines like biotechnology or genomics.

The first decade of the new millennium marked the introduction of "demand pull" priority-setting exercises that focus on major social issues for which science and technology have the potential to make a significant contribution. The issue-based thematic priorities in these exercises are often set out in the form of objectives or challenges and target society in general, not just the research community.

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[29] The term "functional" is used here in reference to the two types of priorities commonly cited by experts, namely structural and operational priorities. The term "functional" was introduced for the first time in the report *Priorities in Science & Technology Policy - An International Comparison* published by a group of European experts in October 2004.

Table 1 — Examples of Thematic and Functional Priorities

Thematic Priorities		*Functional Priorities*
Scientific and Technological	*Issues*	
• Biotechnologies • Chemistry • History • Hydrology	• Eliminate problems associated with urban traffic (Austria, 1998) • Age well and still remain productive (Australia, 2002) • Improve quality of life using prevention (Germany, 2002) • Harvest natural resources more effectively and in line with sustainable development (Québec, 2005)	• Step up industrial research • Promote careers in science and technology among young people • Boost R&D spending to 3% of GDP by 2010 • Increase indirect aid for innovation

Functional priorities were long set by policy and strategy drafters, that is, decision makers assisted by people occupying strategic positions within organizations, ministries, or universities. In recent years, due to the nature, scope, and growing complexity of the problems at issue that require expertise in more and more fields, the process of selecting these priorities has gradually widened to include more stakeholders. These priorities seek to correct certain problems observed upon in-depth analysis of the situation. They are often enshrined in the national budget process and implemented either by government ministries or, as has increasingly been the case in recent years, by various actors within the national innovation system, including government agencies tasked with coordinating science and innovation. Since these priorities deal with major issues that impact the entire innovation system, they are often supported and implemented by more than one stakeholder.

Thematic priorities are generally more controversial since they have a more visible impact on the actual funding of research, and therefore on the researcher's work. They are also more difficult to set since they require a broad view of the evolution of scientific know-how, an understanding of the major social and economic challenges, and a long-term perspective on potential scientific developments. These constraints justify the growing trend to undertake priority-setting exercises as a way to select priorities in an informed and more explicit fashion using a methodological approach that promotes cooperation and collaboration.

The most recent research and innovation plans and strategies developed by industrialized and emerging countries alike point to the growing importance of thematic priorities that fulfill a more political and strategic role. The great social challenges that science is currently tackling – such as climate change, the development of renewable energy, and research into the preservation of ecosystems–are societal concerns that have been integrated into government policies and strategies. These concerns are also often political and they increasingly apply to an ever-growing number of stakeholders. Furthermore, given the importance of strategic global positioning in innovation, some smaller countries have made their strengths in specific thematic areas key planks in their economic development strategies.

1.2.4 A "Portfolio" of Research and Innovation Priorities

Policies, strategies, and action plans for research and innovation generally consist of various types of priorities which, in turn, are often multifaceted. It is not a matter of selecting a single priority, but rather a portfolio of priorities, both functional and thematic, that help:

1) Meet the needs of organizations and businesses, the national innovation system, and major socioeconomic challenges.
2) Stimulate investment in certain key areas with future potential for economic and social benefit.

As Dutch expert Arie Rip[30] points out, the idea of creating a "portfolio" of priorities is derived from the concept of portfolio management, which is based on the principle that one can reduce risk by selecting a range of promising options in different areas. By diversifying one's options, one can compensate for weaker performers and thereby minimize the impact of any "questionable" choices. The idea of opting for scientific thematic priorities (traditional or emerging), technological thematic priorities, issue-based thematic priorities, and major functional priorities all at once also allows those in charge of research and innovation to adopt a strategy that covers as many bases as possible.

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[30] A. Rip (2005), *Research Management From the Top and From Below*. Course material for *Research Management: Institutions and National Science Systems* taught by the author at the University of Twente, Netherlands.

Lastly, choosing different types of priorities is a way to respond simultaneously to the imperatives of demand for new know-how (issue-based thematic priorities) and the supply of knowledge (scientific thematic priorities). As Sarewitz and Pielke[31] put it,

> *The core of our argument is that "better" science portfolios (that is, portfolios viewed as more likely to advance desired societal outcomes, however defined) would be achieved if science policy decisions reflected knowledge about the supply of science, the demand for science, and the relationship between the two.*

This principle of diversity has been at the very core of certain innovation policies in recent years, as illustrated by the examples below.

Sidebar 3 – Diversification of Priority Portfolios: Two Scandinavian Examples

1- Priority portfolio set out in Finland's most recent innovation policy *Science, Technology, Innovation* (2006)

- **Thematic priorities (Finland's recognized strengths)** - forestry industry, metals, and ICT
- **Thematic priorities (promising fields)** - Biotechnologies, new materials, software, advanced knowledge service sector, nanotechnologies, and every aspect of public welfare
- **Functional priorities** - Create and enhance centers for excellence and research clusters in areas in which the country is competitive worldwide, continue to develop topnotch universities that are among the best in the world in areas of Finnish expertise, and develop sectoral research

2- Priority portfolio set out in Norway's most recent white paper *Commitment to Research* (2005)

- **Thematic priorities (issue-based)** - Energy and the environment, oceans, food and diet, health
- **Thematic priorities (scientific and technological)** - New materials and nanotechnologies, biotechnologies, ICT
- **Functional priorities** - Internationalize research, conduct fundamental (or basic) research with an emphasis on natural sciences and mathematics, conduct research to support innovation

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[31] D. Sarewitz and R.A. Pielke Jr. (2007), "The Neglected Heart of Science Policy: Reconciling Supply and Demand for Science", *Environmental Science and Policy*, 10, pp. 5-16, http://sciencepolicy.colorado.edu/admin/publication_files/resource-2485-2007.02.pdf.

1.3 Key Points

In this chapter we have shed light on the growing importance of setting priorities when drafting public research and innovation policies. Following is a summary of some of the key points:

- Priority-setting is not a new phenomenon. Since the 1950s, priorities have been frequently included in research and innovation policies and strategies.
- What is new is the growing sophistication of priority-setting processes as stakeholders strive to rationalize this approach and make it more transparent.
- To understand the growing importance of priority-setting, it is vital to realize the extent of the changes the knowledge society has undergone in the past 20 years.
- The major challenges that many societies will have to tackle in the coming years should spur authorities to adopt targeted and societal priorities.
- There is a diverse range of recognized priorities. Comprehensive and effective policies and strategies should ideally include a portfolio of functional and thematic priorities that address the key imperatives of improving the innovation system, developing scientific and technological knowledge in emerging and high tech fields, and meeting the socioeconomic challenges and needs of the country or region.

The growing importance of priorities in the drafting of research and innovation policies has led a number of international experts to take a closer look at how priorities should be set. Examining the experiences of countries around the world in this regard is a good place to start. If global changes are serving more than ever as a catalyst for priority-setting, how are different countries going about it? How can we create maximum impact and make priority-setting exercises a profitable experience for all the stakeholders in the innovation system? What can Québec learn from priority-setting exercises conducted elsewhere to build its own workable approach? These are all questions that will be addressed in the coming chapters.

Chapter 2
International Priority-setting Experience

In recent years, an increase has been observed in the number of large-scale priority-setting exercises aimed at developing public policies and strategies for research and innovation. Priority-setting is certainly possible without such exercises–as we saw in the preceding chapter priorities are chosen regardless of the approach used. But a large-scale, collective priority-setting exercise that brings parties together helps diversify the portfolio of priorities and meets science and innovation management requirements (governance, transparency, etc.). These structured experiences primarily tend to make explicit a process that often unfolds implicitly. As a result, outcomes are much broader in scope, and the impacts of such exercises concern the entire population.

The literature on priority-setting in research and innovation points to a number of exercises conducted over the past 20 or 30 years. Many of them are worth looking at because they suggest innovative approaches or draw on a strict methodology, or because their outcomes were disseminated broadly and their impacts on the community are significant.

With a view to producing this report, Conseil de la science et de la technologie made a list of over 70 major priority-setting exercises conducted around the world since the mid-1990s.[32] Detailed descriptions of some twenty of these discuss:

- The purpose of such exercises.
- How these exercises were put together (methods).
- How priorities were selected (criteria).
- The role of stakeholders.
- The resulting outcomes.
- Possible impacts of such exercises and methods used to assess the priority-setting process as a whole.

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[32] This list, presented in Appendix 1 of the advisory report, is not exhaustive. It was developed to cover as many countries as possible while including a sufficient number and variety of priority-setting exercises. International experts consider many of these exercises exemplary.

This overview of international experiences[33] shows that many countries have undertaken priority-setting exercises. Some of them, including Japan, the United Kingdom, France, the United States, the Scandinavian countries, and several European Union countries, have an extensive and well-established priority-setting tradition. Others began carrying out major priority-setting exercises recently but are rapidly acquiring considerable knowledge on the subject. These include China, South Korea, and certain South American countries.

Looking at recent priority-setting experiences around the world also provides an opportunity to consider similarities and differences. While several major priority-setting exercises have served to define functional priorities,[34] most have been used to set thematic priorities. The very nature of a priority is thus important, particularly as regards the method used to set it. This is a key point to keep in mind in considering the types of priority-setting exercises in order to classify them.

2.1 Types of Priority-setting Exercises

Analysis of the priorities selected in different priority-setting experiences reveals four main types of exercises for determining research and innovation priorities. As mentioned earlier, this classification is based primarily on the nature of the outcomes of the various exercises under consideration. While other classification criteria could have been used, outcome was chosen because this is what determines all the decisions going forward. This criterion influences the main project objectives, the participants chosen to take part in the exercise, and the methods used. For example, you do not use the same methodology to identify emerging technologies and major social issues.

Sometimes priority-setting exercises lead to more than one type of thematic priority. Such exercises form a new "mixed" category. They require a more complex approach and a multistep method, and are often recommended in national priority-setting initiatives tied directly to the development of research and innovation policies or strategies.

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[33] For an outline of recent priority-setting developments in different parts of the world, see Appendix 2, "Priority-Setting: An Overview of International Experience."

[34] Including the United Kingdom's Foresight Programme, for example.

Table 2 — Priority-setting Exercise Classifications Based on Outcome

Orientation	Type of Priority-setting Exercise	Sample Outcomes
Market/industry	**Critical technologies** Identification of technologies that can significantly boost a country's economic development. "Technology roadmap" exercises are also part of this category.	• Nanostructure and nanocomposite materials • Third-generation nuclear reactors • Environmental technologies
Science	**Scientific research priorities** Determination of priorities in major scientific fields or specific research areas.	• Aeronautics • Neuroscience • History • Nanotechnology
Society	**Social-problem solving** Identification of major socioeconomic challenges or issues that scientific research and development will attempt to address in the coming years.	• Climate change • Sustainable development • Population aging
Multiple (industry, science, society)	**Mixed exercise** Combination of two or three of the abovementioned types.	• A portfolio of diversified priorities

2.1.1 "Critical Technology-oriented" Priority-setting Exercises

These exercises are aimed primarily at identifying promising or emerging technologies that a region or country should invest in to increase its competitive position nationally and internationally. Used largely since the 1980s, many of these priority-setting exercises have become classics of their kind, particularly in the United States and France.

The approach centers mainly on the market and industry, the idea being to encourage the development of businesses active in high tech sectors while spurring research in these critical technologies. These exercises have been popular since the 1990s, particularly because of increasingly strong ties between technological innovation and economic development.

Table 3 — Examples of "Critical Technology-oriented" Exercises (all using foresight methods)

Belgium	**Programme Prométhée 1 - 40 Critical Technologies (1998-2000)** This project under the responsibility of the Walloon region was conducted in cooperation with a consulting firm and Bureau federal du Plan (Federal Planning Bureau). It targeted a total of 40 critical technologies with strong potential for the region for the next ten years. It featured a significant consultative and participative dimension, and sought to leverage new knowledge opportunities while taking social demand into consideration.
Canada	**Technology Roadmaps (since 1996)** Technology roadmaps are aimed at identifying the technologies needed to support strategic R&D, marketing, and investment decisions. These technologies are likely to be of key importance for an industry in five to ten years. Developed by Industry Canada together with business, technology roadmaps also help determine the competencies required to properly use the technologies of tomorrow.
United States	**National Critical Technologies III (1995)** Exercise comprising a significant consultative dimension (experts) that helped identify 27 main technology sectors of key importance for the country. This project was led by a work group created for the occasion and consisting of members of the President's Committee of Advisors on Science and Technology (PCAST).
France	**Technologies Clés 2010 (Key Technologies) (2004-2005)** Exercise that set national technology priorities based primarily on available new technologies. It consisted of a significant consultative (experts) and participative (tour of the regions) dimension. This initiative of ministère de l'Économie, des Finances et de l'Industrie (France's Ministry of the Economy, Finance, and Industry - MINEFI) helped target 83 key technologies.
Ireland	**Technology Foresight Ireland (1997-1999)** This national priority-setting exercise under the responsibility of the Irish Council for Science, Technology, and Innovation (ICSTI) put forward a mixed approach that was both participative and consultative (panels of experts). A series of strategic technologies were identified, and recommendations and suggestions were made regarding mechanisms to properly implement these technologies.
Czech Republic	**Technology Foresight 2002 (2001-2002)** Exercise aimed at setting national priorities. Consisting of a significant consultative dimension and a highly analytical component, the project identified 90 critical technologies (and their associated research sectors). Technology Foresight 2002 was led by Ministry of Education, Youth, and Sports (Ministerstvo školství, mládeže a t lovýchovy) as well as Council for Research and Development (Rady pro výzkum a vývoj).

The methodology specific to this type of priority-setting exercise consists of applying a series of criteria[35] to determine the importance (or critical mass) of a technology and its impact on wealth creation and improved quality of life. A "critical technology" exercise is generally carried out with scientific or industrial experts who analyze the potential and possible impact of a targeted technology.

In addition to leading to the creation of networks and programs designed to develop selected critical technologies, this type of exercise is often tied to the creation of industrial or competitive clusters.

2.1.2 "Scientific Research-oriented" Priority-setting Exercises

These priority-setting exercises are aimed at identifying major scientific disciplines that research development leaders should view as "priorities" for a given country or organization. These exercises are commonly used by granting agencies, ministries responsible for research, and university institutions.

The methodology of this type of exercise centers primarily on the consultation of experts able to reflect on the medium or long-term development of scientific knowledge. This structured reflection makes it possible to determine the most promising research fields according to the strengths of the organization or business.

Table 4 – Examples of "Scientific Research-oriented" Priority-setting Exercises

Canada (Alberta)	**R&D Priority-setting Consultation: Guidance Toward an R&D Strategy for Alberta (1995-1996)** This exercise aimed at identifying research priorities, had a qualitative and quantitative methodology, and featured a significant consultative dimension (experts). Under the responsibility of Alberta Science and Research Authority (ASRA), the exercise identified nine major and seven secondary priorities.
Canada (federal)	**Procedure Used by Natural Sciences and Engineering Research Council of Canada (NSERC) to Identify New Target Fields and Research Subjects (2003-2005)** Exercise aimed at identifying research priorities for an organization. Led by the NSERC Committee on Research Partnerships, the project featured a significant consultative dimension (experts). It identified a total of seven specific fields to support the strategic project grants selection process.

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[35] For more details on the criteria used in this type of exercise, see the observation on "selection criteria" on page 50 of this report.

Table 4 (suite)

Denmark	**Innovation Accelerating Research Platforms (2004-2005)** Project under the responsibility of the Danish Strategic Research Council (Det Strategiske Forskningsråd - DSF) aimed at setting national priorities. Featuring a consultative dimension as well as a participative component, the project identified ten strategic research platforms. This priority-setting exercise was part of the DSF's mandate.
Hungary	**Hungarian Technology Foresight Programme (1997-2000)** A foresight exercise aimed at identifying national research priorities. Featuring a significant consultative dimension (experts), the exercise was aimed primarily at determining the possible direction of certain major research fields and subsequently identifying those in which Hungary had the best chance of excelling in the coming years

A number of granting agencies use the priorities identified in these exercises to target funds to appropriate research projects.

- The Natural Sciences and Engineering Research Council of Canada exercise is tied to the Strategic Project Grants Program.
- The Danish platforms are part of the mission of the Danish Strategic Research Council, an advisory body dedicated to funding strategic research projects.
- Science Foundation Ireland recently established the Strategic Research Clusters 2008 program to stimulate industry/university research partnerships in both of the country's priority fields–ICT and biotechnology.

These exercises help determine the priorities that will guide creation of major research programs funded by the public sector or in partnership with private business. Germany takes this approach, having established thematic programs several years ago such as the Optic Technologies Program, the FoNa Research for Sustainability Program, and the Microsystem Framework Program.

2.1.3 "Social Problem-oriented" Priority-setting Exercises

In the 2000s, new types of priority-setting exercises emerged that emphasize major social problem solving. A number of countries increasingly concerned about the relationship between science and society have opted for this type of exercise, which not only makes it possible to target research priorities that contribute to public welfare, but also to connect scientists with society, for the greater good.

This type of priority-setting exercise identifies challenges or specific issues affecting society that science and technology can address. It leads to the establishment of new types of priorities that no longer target genomics, ICT, or life sciences, for example, but disease prevention, climate change, or public safety. In this approach, technologies and research disciplines are seen as tools for tackling the identified challenge.

Table 5 — Examples of "Social Problem-oriented" Priority-setting Exercises

Country	Overview
Germany	**Futur - The German Research Dialogue (2001-2005)** Project under the responsibility of Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung - BMBF) conducted by a consortium of public agencies and private businesses with a view to identifying national priorities. Featuring a significant participative dimension, this exercise based on social demand for new knowledge identified four socioeconomic challenges and three main technology trends.
Australia	**National Research Priorities (2002-2004)** Project under the responsibility of the Australian government aimed at determining national research priorities. Calling on both experts and ordinary citizens, the exercise featured a significant consultative dimension and identified four major problem-oriented priorities.
Finland	**FinnSight 2015 (2005-2006)** Project carried out jointly by Academy of Finland (Suomen Akatemia) and Finnish Agency for Technology and Innovation Funding (Tekesin - Tekes) aimed at setting national research priorities. Based on social demand for new knowledge, it featured a significant participative dimension. The outcomes suggested five problem-oriented priorities.
Denmark	**Research 2015 (2008)** Project conducted by Ministry of Science, Technology, and Innovation (Ministeriet for Videnskab, Teknologi og Udvikling) with the participation of the country's research and innovation stakeholders from associations, universities, and industry. This project, which drew links between Denmark's main social challenges and its research requirements and resources, identified six main strategic research priorities for the next ten years.

The methodology used is generally highly participative and puts the emphasis on social demand for new knowledge. Various types of stakeholders are involved, and priority-setting activities often include workshops, public polls or surveys, and large conferences. Decision-making usually aims to achieve consensus.

As cooperation is among the benefits of these exercises, priority-setting often leads to the creation of strategic partnerships among a number of researchers. The themes identified in this type of exercise call for a multidisciplinary approach.

2.1.4 *Mixed Exercises*

These three subclassifications are neither exhaustive nor exclusive. A single priority-setting exercise may be "mixed," i.e., include elements of two different types. This situation can be observed in the following priority-setting exercises.

Table 6 — Examples of "Mixed" Priority-setting Exercises

Country/Title/Summary	Selected Priority Types
Spain **Fourth National Research Program (2000–2003)** Exercise to determine national research priorities under the responsibility of the Interministerial Science and Technology Commission (Comisión Interministerial de Ciencia y Tecnología). This broad consultative exercise involving a variety of stakeholders led to the identification of 21 priorities expected to contribute directly to Spain's national plan for scientific research, development, and technology innovation.	• Scientific research priorities • Thematic issue priorities
European Commission **Emerging Thematic Priorities for European Research (2000)** Foresight project under the responsibility of Institute for Prospective Technological Studies (IPTS) aimed at identifying supranational priorities. The exercise featured a significant consultative (experts) and analytical dimension targeting major issues, as well as a number of emerging research fields and certain technologies that could play a key economic and social role for Europe.	• Scientific research priorities • Topical themes
Japan **Eighth Science and Technology Foresight Survey (2035) (2003-2004)** Foresight exercise that set national research priorities. Under the responsibility of National Institute of Science and Technology Policy (NISTEP), this exercise is a main source of information for the Science and Technology Basic Plan. It looks at new available knowledge, but in recent years has also taken social demand into account. The Japanese Delphi approach is considered a classic of its kind and has inspired many countries in their priority-setting and foresight initiatives.	• Scientific research priorities • Topical themes • Technological priorities • Functional priorities

Table 6 (suite)

United Kingdom **Foresight Programme (1st round) (1994-1999)** Foresight exercise that set national research priorities. Under the responsibility of Office of Science and Technology (OST), Foresight Programme helped identify thematic priorities for research, major scientific fields for the future, and a number of functional priorities. This exceptionally long-lived priority-setting exercise is also considered a classic, and has inspired many countries since the 1990s.	• Scientific research priorities • Technological priorities • Functional priorities

While there is no hard and fast rule, we observe that certain countries tend to take a mixed approach to creating science and technology plans, policies, or national strategies. This has resulted in methods that are more cumbersome and entail numerous phases, involve more stakeholders, and sometimes require coordination to ensure consistency. While complex, these experiences can be highly effective. Japan, for example, has long been recognized as a pioneer in this type of mixed approach using a number of different priority-setting methods.

2.1.5 Hackmann Typology

In her doctoral thesis published in 2003, Heide Hackmann[36] suggests a typology that complements the one discussed above and is based on the priority-setting process rather than the nature of the outcomes achieved. To build her typology, Hackmann took a macro approach using the "country" unit as the basic referent and observing how priorities are set within certain geographic boundaries. Her observations gave rise to two priority-setting processes, one *de facto* and the other explicit.

In the ***de facto*** process, priorities emerge retrospectively from existing activities and structures, without these priorities being formally stated. They arise from political or institutional choices made over the years and traditionally carried over without a specific mechanism for this purpose. De facto priorities are part of the budget and strategic planning of the body that implements them, and they dictate the research focus for the program, university, or research institute in question. For example, the thematic and functional priorities that have guided a country's research and innovation efforts are reflected in the national research programs put in place over a certain period.

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[36] H. Hackmann (2003), *op. cit.*, p. 274.

In the **explicit** process, targeted priorities fall within a specific framework outside traditional strategic planning, requiring the formal use of an external and open priority-setting mechanism. Generally based on foresight planning, these priorities are often predominantly national, apply to a number of stakeholders in the innovation system, and require ongoing consultation and coordination. Explicit priority-setting involves a more systematic and rational approach, is often recurring, and entails a carefully developed method.

Table 7 — Typology According to Priority-setting Process (Hackmann, 2003)

Characteristic	*De facto* Priority-setting Process	Explicit Priority-setting Process
Priority-setting	Informal *ad hoc* process.	Formal systematic process.
Priority-setting instruments	Activities specific to each organization (may, however, require ad hoc consultations, lead agency briefs, etc.).	Most often an aid to foresight and other methods (exercises planned to structure the process, often recurring).
Involvement of other public or private stakeholders	Low or medium degree of consultation (stakeholders play a consulting role).	High degree of consultation (diversified stakeholders can take part as decision makers).
Impact	Generally has an impact on stakeholders involved in a specific research program or with a particular institute or organization. May have no impact on the rest of the NIS.	Generally has an impact on all NIS stakeholders.
Examples	Funds earmarked for a research field on account of such factors as the periodic extension of previous budget decisions or the influence of certain pressure groups.	Major national priorities are set after consultations and negotiations between stakeholders.

Hackmann notes a trend in recent years to take a more explicit priority-setting approach that helps systematize exercises and make the priority-setting rationale more transparent. Among other things, this trend is part of the new worldwide socioeconomic dynamic of placing greater importance on science and technology in wealth creation, thereby spurring the adoption of new governance practices in public research and innovation management. This trend also helps explain the increasing popularity of these exercises.

These more explicit priority-setting exercises also help identify priorities that have an impact on a growing number of stakeholders. As such, the human factor tends to increase in importance according to the explicitness of the priority-setting process. While exercises vary in impact from one experience to another, they are attracting more and more attention from experts. These impacts are largely the result of priority implementation processes, whether or not planned by those in charge of the exercise.

2.2 Impact and Implementation of Priorities

Regardless of the type and nature of the exercise, setting research and innovation priorities always has an impact on how research is organized. The extent of the impact varies from one exercise to another, however, depending on how the results are used by the principal stakeholders. For example, in Australia the National Research Priorities have had a huge effect on all public research bodies, regardless of sector (the environment, social policy, the economy, etc.). Other exercises, mostly pilot projects, have had a more modest influence on policies and public management of research.

According to Hackmann,[37] the impact of a priority-setting exercise chiefly depends on the status accorded the priorities, which determines how they will be implemented by government and the stakeholders involved. Hackmann observed that the priorities' status primarily flows from four factors: 1) their role, 2) the significance conferred on them, 3) their scope, and 4) the financial resources allotted to them.

1. The goals of the priority-setting exercise determine the priorities' role

Some priority-setting exercises are simply to inform future policies and strategies. They have political backing, so their impact and funding are assured. In other cases, priority-setting has other objectives, such as better coordination between stakeholders or a strengthening of an organization's or ministry's political power. When this is the case–the priority-setting exercise is a tool rather than a goal–there is no guarantee the priorities will be acted on or even remain priorities.

2. The importance accorded a priority depends on how we perceive its significance

The nature of the priorities set can be interpreted in different ways by various stakeholders in the national innovation system. Hackmann cites the example of the priorities identified by the United Kingdom's Foresight Programme. Because of their "technological" nature, they had difficulty capturing the interest of the university research sector, which is traditionally more oriented towards the development of science. Priorities should therefore not be inappropriate for the environment in which they will be implemented.

3. A priority should be neither too broad, nor too narrow

Certain priorities cover a broad spectrum of themes, sometimes expressed in the priority statement itself. Setting the broad category "social sciences and humanities" as a priority opens the door to a myriad of initiatives that could be perceived as ineffective because their scope is too broad. A priority that is too obvious (one that has long been recognized as such by authorities), too vague, or whose goals are too general risks being interpreted as no priority at all, thus invalidating the exercise that established it.

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[37] H. Hackmann (2003), *op. cit.*, p. 216.

4. A priority is most likely to be achieved if it is part of a long-term strategic and financial plan

The budget is a mechanism by which priorities can be entrenched in an implementation strategy, thus ensuring that stakeholders in the national innovation system address it. Earmarking additional research funds exclusively for a given priority indicates that decision makers are serious about achieving its objectives. The same is true for the strategic plan framing the priority-setting exercise. Generally speaking, priority-setting is an activity that signals a desire to establish a long-term vision, which therefore requires planning.

In the past, **the scientific impacts** of priority-setting exercises were the main things emphasized, particularly by researchers, but also by public research administrators (universities, granting agencies, etc.). The fear has often been expressed that directed research curtails researchers' freedom and access to public funds. As we discussed in Chapter 1 of this report, socioeconomic changes and the conditions under which research is now conducted tend to ease concerns with regard to this type of repercussion–basic research remains a recognized priority in many countries. Public officials generally acknowledge its importance in the development of knowledge worldwide and are aware of the extent of its contribution to strategic or thematic research.

More recently, and despite ever present–and essential–interest in scientific impacts, more and more attention is being paid to the **community and administrative impacts** of the priorities chosen, and thus to results other than scientific ones. Pressure on governments to justify funds invested in certain projects in terms of these types of impacts has contributed to this change. However, other factors, such as new methods of governance and requirements for transparency and sound management, have also led authorities to take an interest in community and administrative impacts. Thus, to increase the impact of priorities selected in a priority-setting exercise, many bodies have developed mechanisms to implement their research and innovation priorities more effectively.

2.2.1 *First Implementation Mechanism: The Budget*

According to OECD, budgets are an essential mechanism for implementing priorities because no priority will actually be a priority if it does not result, in one way or another, in the allocation of adequate funding.[38] Priorities backed by a policy or strategy are more likely to be funded and thus benefit from the related budget. This funding is the first essential step in their implementation.

Sometimes funding is broken down by priority, as in the case of Germany's most recent High Tech Strategy.[39]

Table 8 — Funding for Germany's High-tech Strategy by Thematic Priority, 2006 to 2009

Seventeen High-tech Sectors	Funding Granted (in millions of euros)	Total Funding (percentage)
Space technologies	3 650	30.6
Energy technologies	2 000	16.8
Information and communication technologies	1 180	9.9
Health research and medical technology	800	6.7
Automotive and traffic technologies	770	6.4
Nanotechnologies	640	5.4
Biotechnologies	430	3.6
Environmental technologies	420	3.5
Materials technologies	420	3.5
Optical technologies	310	2.6
Plants	300	2.5
Aviation and aeronautical technologies	270	2.3
Production technologies	250	2.1
Microsystems technology	220	1.8
Maritime technologies	150	1.3
Security research	80	0.7
Services	50	0.4
Total	**11 940**	**100**

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[38] OECD (1991), *op. cit.*, p. 45.

[39] Federal Ministry of Education and Research (2008), *Our Implementation of the High-Tech Strategy*, http://www.bmbf.de/en/6618.php.

Table 9 – Funding for German High-tech Strategy by Functional Priority, 2006 to 2009[40]

	Funding Granted (in millions of euros)	Total Funding (percentage)
Improve conditions for innovative SMEs	1 840	69.2
Bundle the forces of science and industry	600	22.6
Support technology startups	220	8.3
Total	**2 660**	**100**

The German federal government thus planned to invest more than €15 billion (approximately $23 billion) in this strategy between 2006 and 2009 to enable the country to fulfill one of its chief functional priorities, namely to boost R&D investment to 3% of GDP by 2010. Of this €15 billion, €12 billion (approximately $19 billion) was specifically earmarked for priority technology sectors.

The funding of priority sectors also crops up in the budget process of public research bodies. For example, Tekes in Finland has for many years identified strategic focus areas. About half Tekes's total budget is earmarked for technology programs. Part of each program is also funded in partnership with the participating businesses or research centers. These research programs are established in strategically important R&D sectors, which Tekes has targeted in concert with representatives of the business and research communities and of society at large.[41] In 2006 Tekes funded 23 strategic technology programs, for a total of €190 million (approximately $300 million), or 41% of the organization's total budget.

The United States has long used the budget process to promote presidential research and development priorities. Every year, a memorandum from the Executive Office of the President and the Office of Science and Technology Policy is sent to department secretaries and federal agencies.

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[40] Federal Ministry of Education and Research (2008), *op. cit.*

[41] Tekes identifies applications focus areas, technology focus areas, and promising areas in clusters.

The document does not specifically earmark funds for individual priorities. Instead, investment is shared out among the various research agencies or, in more specific cases, earmarked for national thematic initiatives (nanotechnologies, for example, have their own operating budget). For fiscal year 2009, the United States has targeted the following broad priority areas in its budget planning:

- Homeland security and national defense.
- Energy and climate change technology.
- Advanced networking and information technology.
- Nanotechnologies (through the National Nanotechnology Initiative).
- Understanding complex biological systems.
- Environment.
- Next generation air transportation system.
- Federal collections of scientific objects and artifacts.
- Science of science policy (impact of R&D investment, measuring impacts, etc.).

Each of these priorities or specific themes is broken down into subthemes cited in the document, and agencies and organizations, including universities, are encouraged to concentrate on these particular research fields. Since 2006, the priority-setting process has been closely tied to the United States' most recent economic strategy, the American Competitiveness Initiative. This strategy, in addition to targeting various sectors, identifies basic research as one of its chief priorities, particularly in the fields of physics, mathematics, and engineering. It provides $1.3 billion in additional R&D investment, most of which is shared by National Science Foundation, Energy Department, Office of Science, and National Institute of Standards and Technology.

The explicit listing of national priorities in the budget process is an extremely effective mechanism that lends them visibility and assures funding for their implementation. In Australia, for example, the country's four national priorities are linked to the strategic planning of public research bodies. Their implementation is thus assured by both the budgets set aside for the government strategy Backing Australia's Ability and by the operating budgets of the various research organizations.

2.2.2 *Other Implementation Mechanisms*

Functional priorities are often funded through official mechanisms, in the form of targeted financial investments, through the creation of programs or organizations that provide aid and support to innovation stakeholders. Specific medium and long-term action plans can also help implement solutions designed to address the priority.

Scientific thematic priorities or issues identified by governments can spur the creation of research groups, research institutes, research chairs, or broad programs, which are usually multidisciplinary and involve a large number of researchers. These priorities often generate strategic grants, distributed by government research funding bodies.

As for companies, they are often brought in when thematic priorities are technological in nature and require concerted effort in the research and development of marketable applications. The most common examples of company involvement in implementing priorities concern technology clusters and platforms.

The term "technology cluster" designates the gathering of a large number of innovative companies around a nucleus of R&D facilities, suppliers, and venture capitalists. It is a proactive structure that involves various stakeholders in a community of interests characterized by ties of complementarity and interdependence, each company voluntarily forging collaborative ties in one or more technology fields.

In recent years many governments[42] have opted to establish technology platforms. A technology platform is to bring all concerned stakeholders together to craft a long-term research plan for a given technology. Both public and private funds are central to this effort, as are setting up a flexible governance structure and ensuring balanced participation by all stakeholders. Technology platforms also seek to tailor research priorities to industry needs. They embrace the entire economic chain, transforming the knowledge generated by research into technologies and processes, and eventually into marketable products and services.[43]

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[42] This is particularly true of the European Commission, Denmark, and the Netherlands.

[43] Definition according to the European Commission, 2007.

Sidebar 4 – Implementation of Priorities: The Case of Australian Research Council-ARC[44]

In a national research priority implementation plan submitted in 2003, Australian Research Council proposed a series of measures under three main objectives. Each of these objectives comprised a specific strategy, actions to carry out, and related funding.

The first goal, "Build the Scale and Focus of Research," advanced a strategy focused on creating new centers of research excellence in national priority sectors. ARC planned to earmark 73% of new research funds for national priorities, a 60% and 61% jump respectively compared to 2001 and 2002.

The second goal, "Encourage Interdisciplinary Approaches to Research," emphasized interdisciplinarity and the creation of research networks. ARC chose to increase financial support to interdisciplinary research by boosting funding from 23.1% in 2001 to 27.5% in 2002, and 32.6 % in 2003.

The third goal, "Facilitate Collaborative Approaches to Research," also concerned research networks, as well as international cooperation in the country's priority sectors. The goal called for measures to direct funding to certain research activities to foster international cooperation and the development of research networks.

The Australian Research Council's strategy for implementing research priorities proposes adopting a number of measures to give concrete expression to these goals. The main actions are centered on three measures:

1 Creating thematic centers of excellence on national research priorities.

2) Changing researchers' work methods by encouraging interdisciplinarity and networking.

3) Facilitating collaborative research with international partners on themes covered by Australia's national priorities.

ARC is not the only body to have such an implementation plan. In all, 24 public bodies in Australia have produced such plans in the wake of the setting of national research priorities. These organizations hail from various sectors where research has a big impact, such as agriculture, fisheries & forestry, defense, the environment, education, science, and training.

2.2.3 *Recording and Measuring the Impacts of Priority-setting*

The importance accorded to the impacts of public research and its priorities has spurred unprecedented interest in evaluation tools for measuring these impacts. According to OECD, "evaluation has high and increasing priority as an essential part of governance and policy implementation. The main motivation is to increase the efficiency and effectiveness of innovation policy programmes.[45]"

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[44] Australian Research Council is an advisory body under the jurisdiction of the Minister of Innovation, Industry, Science, and Research. Its mission is to stimulate Australian research to be competitive and of benefit to the community. Created in 2001 by the *Australian Research Council Act*, the Council is also a key research funding body in Australia.

[45] OECD (2006), *op. cit.*, p. 93.

Since the beginning of the new millennium, many organizations specialized in the study of public policy (such as Manchester Institute of Innovation Research [PREST] or Science and Technology Policy Research [SPRU]) have taken a critical look at a number of priority-setting exercises, particularly those with a foresight approach.[46] Up till now, priority-setting exercises have mainly been evaluated on **process** rather than **results**. This stems mainly from two factors:

1) The priority-setting exercises evaluated were mostly exploratory–in order to stabilize and strengthen their methodological processes, those in charge of the priority-setting exercises mainly paid attention to process in order to improve the method and make the exercises more effective in the future.
2) The evaluation of priority-setting exercises has only been developed in the last few years, and the programs and initiatives to implement priorities are often too recent to evaluate their impacts and spinoffs.

Evaluating the priority-setting process has a definite advantage however–it reveals the importance of the **social impacts** of priority-setting exercises on all stakeholders in the innovation system. These social effects will be discussed in more depth in Chapter 3 of this report.

Another evaluation strategy consists of examining programs set up in the wake of a priority-setting exercise for the purpose of implementing the various priorities selected. For example, Tekes in Finland evaluates its technology programs twice, at mid-term and at the end of their period of application. This is done by a group of experts from outside the organization who study the program's research dynamics, development practices, and success and failure factors. Various countries with programs to implement thematic priorities carry out evaluations of this type, if only for the purposes of extending or canceling funding.

Reaping the Benefits of International Experience

Whether we concentrate on priority-setting or on the potential impacts and results of the process, international experience helps advance knowledge in these fields. After examining priority-setting exercises (description, implementation mechanisms, and the growing interest in their impacts), what conclusions can we draw to guide stakeholders in selecting the most intelligent and strategic approach for Québec? A certain number of observations can be made before looking specifically at Québec's experience in priority-setting.

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[46] For more information on these evaluation exercises, see chapter 3, page 58.

Chapter 3

Findings and Observations Drawn from International Experience

Ten Observations Drawn from International Experience

The various priority-setting experiences studied in this advisory report have provided greater insight on the way priority-setting exercises are designed and conducted around the world. This has given rise to certain general observations.

These findings can shed light on how Québec could draw up an approach to priority-setting in research and innovation. What should we learn and take away from these experiences?

The following table sums up the observations that can be drawn from priority-setting experience at the international level. These observations will be explained in greater detail in the pages that follow.

Table 10 – Ten Observations on Research and Innovation Priority-setting

Observation 1	The priority-setting exercises conducted in the last 15 years have been an opportunity to experiment with new methods and approaches.
Observation 2	As a general rule, priority-setting exercises begin as political initiatives, but are run by various bodies.
Observation 3	Priority-setting exercises generally involve numerous stakeholders from an increasingly wide range of backgrounds.
Observation 4	The greater the importance political leaders publicly accord the priority-setting process, the greater its odds of success.
Observation 5	Major priority-setting exercises tend to take quite specific approaches that draw on a variety of methods but follow a relatively similar logic.
Observation 6	Exercises often identify priorities on a medium and long-term time perspective, which makes foresight a growing concern in priority-setting.
Observation 7	Priority-selection criteria are usually based on the notions of attractiveness and feasibility.
Observation 8	The seeming convergence of national thematic priorities around the world does not rule out a higher level of diversity within each country.
Observation 9	The impact a priority-setting exercise has is contingent not only on the results it yields (list of priorities), but particularly on the manner in which the priority-setting process is designed and carried out as a whole.
Observation 10	Evaluating priority-setting exercises helps provide a better understanding of the tangible and intangible impacts of the exercise, while improving the priority-setting practices of a society or organization.

Observation 1

The priority-setting exercises conducted in the last 15 years have been an opportunity to experiment with new methods and approaches.

A number of recent priority-setting exercises were first-time attempts by both the organizations commissioning them and those conducting them. In other cases a new approach or method was being tried. Indeed, priority-setting is often perceived as the perfect opportunity to experiment with different approaches and introduce new combinations of innovations in processes and methods. The German Futur project is a good example of this with its new take on priority-setting designed to bring about organizational change and get more stakeholders involved in the decision-making process.

A number of these pilot projects remain isolated experiments that help determine an organization's priorities for the next policy or strategy in the works. However, other exercises, because of their success and particularly because of they benefits they bring, become the norm and are regularly repeated. This is notably the case for the Delphi studies in Japan (eight conducted so far), Critical Technology initiatives in France (the third exercise was published in 2007), and the Foresight Programme in the United Kingdom (the third round is currently under way).

This finding is somewhat indicative of the growing popularity of priority-setting. All the exercises discussed in this advisory report were selected primarily for the amount of detailed information available on the experience. In other words, more and more countries are conducting their own priority-setting exercises using a methodology elaborate and rigorous enough for the experience to be viewed as inspiring for others.

Observation 2

As a general rule, priority-setting exercises begin as political initiatives, but are run by various bodies.

Most of the time, decisions to undertake priority-setting exercises are made by government ministries or agencies in charge of managing and funding research and innovation. They incorporate the results of these activities into their strategic planning processes and their research and innovation policies. The task of actually running priority-setting exercises often falls to various officials in charge of coordinating the process. Political influence is therefore offset by the variety of stakeholders represented and the diversity of voices.

Priority-setting may be delegated to advisory bodies, research funding organizations, or official working groups created specifically for the purpose. It is also common for the business community to take part in overseeing and conducting priority-setting exercises. Some steps, like major public consultations or surveys of researchers, are sometimes contracted out to private companies with special expertise in the field.

Sidebar 5 – Responsibilities for Various Priority-setting Exercises

- The 2002 Technology Foresight initiative by the Czech Republic was placed under the shared responsibility of Ministry of Education, Youth, and Sports and Council for Research and Development (Rady pro výzkum a vývoj). However, the project was coordinated by a consortium of three organizations: Technology Center (Technologické centrum AV R), Academy of Sciences of the Czech Republic (Akademie v d eské republiky), and Engineering Academy of the Czech Republic (Inženýrská akademie eské republiky).
- In France, the most recent Key Technologies 2010 initiative was overseen and coordinated by ministère de l'Économie, des Finances et de l'Industrie (Ministry of the Economy, Finance, and Industry). The study was conducted by a consortium of companies (Futuribles, Cybion, Virtuoz, and Biotics) and led by the Erdyn innovation consultancy firm.
- In the United States, the National Critical Technologies List in 1995 was placed under the responsibility of National Critical Technologies Group, which was created specifically for this purpose and reported to the U.S. Congress. The group included a few members of President's Committee of Advisors on Science and Technology. Rand Corporation's S&T Policy Institute, National Science and Technology Council, Committee on Civilian Industrial Technology, and Committee on National Security were also involved in this exercise.

Certain exceptions arise when priority-setting is part of an organization's core mandate. This is notably the case for Danish Council for Strategic Research (DSF), whose mission is to fund research in key strategic fields. To fulfill its mission, DSF implemented the *Innovation Accelerating Research Platforms* project, which allowed it to identify ten strategic research platforms.

Observation 3

Priority-setting exercises generally involve numerous stakeholders from an increasingly wide range of backgrounds.

The vast majority of the priority-setting exercises discussed in this report has broad participation, calling on stakeholders from industry, government, the scientific community, and civil society, as the case may be. OECD confirmed this trend, viewing it as a development designed to increase transparency and better meet society's needs.[47]

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[47] OECD (2003), *Governance of Public Research: Toward Better Practices*, Paris, OECD, p. 83.

Although the number of participants can vary considerably, priority-setting initiatives often involve hundreds of stakeholders:

- The German Futur project involved some **1 200** participants from nonprofit organizations and from the fields of research, education, culture, and industry-and this was just for Phase I of the project.
- Finland's FinnSight 2015 project brought together **120** experts from the fields of science, technology, business, and social policy.
- Some **200** people from economic, science, finance, union, and government backgrounds took part in Belgium's Prométhée 1 project.
- NSERC's priority-setting initiative conducted between 2003 and 2005 called on some **500** university researchers, **100** industry representatives, and **125** researchers from government and nongovernmental organizations, as well as a number of research managers and public policy officials.

The increased variety of the stakeholders involved is notably due to the fact that priority-setting is largely dependent on the level of expertise that goes into decision-making. This expertise may be "academic" (knowledge-based), but the complexity of science and innovation issues tends to broaden the type of expertise needed to other stakeholders who also possess a high level of know-how. They will be asked to take part in all phases of the exercise, not only to assess the current situation of a given issue, but also to anticipate the possible future developments of a particular technology, discipline, or field of research.

Today's new priority-setting exercises, which are designed to identify major future challenges or solve specific social problems, are by nature efforts of collective reflection that call on a high number of stakeholders. These exercises are also most likely to include individuals from civil society–whether through extensive surveys, focus groups, or events designed to foster communication and consensus. The growing popularity of priority-setting exercises that target thematic priorities partially explains the marked interest in the broader, more open involvement of stakeholders from various backgrounds.

Observation 4

The greater the importance political leaders publicly accord the priority-setting process, the greater its odds of success.

Some specialists believe that exercises that benefit the support of decision makers-and sometimes even their participation at certain stages of the process–have the greatest odds of seeing their results incorporated into specific programs and activities. Although political leaders are often called on to play a "client" role, their involvement in priority-setting exercises can take a variety of shapes.

Examination of international experiences points to three types of contributions political leaders make to priority-setting exercises, with each type characterized by certain advantages and disadvantages.

Type one: patronage

By definition, a patron is an individual or corporation that provides material support for a work or a person to conduct activities presenting a public interest, without intending to make a profit and without receiving direct consideration. As such, a priority-setting exercise may be hailed by authorities or receive government financial support. It will, however, be carried out by another organization or partner, and the role of political leaders does not extend beyond pecuniary and moral support. Decision makers are thus free to choose whether or not to adopt the priorities identified in the process.

However, with the government's role confined to providing financial or moral support, there is no guarantee that the results will be used or that the priorities will be implemented.

Type two: official request

For the second type of contribution, political leaders and main national innovation system stakeholders must first recognize the need to set research and innovation priorities. Priority-setting is thus political in origin and often enshrined in official documents (policies, strategies, action plans) where it receives direct support (financial and moral) for its implementation.

With the initiative coming from political leaders, the process has greater value and is more legitimate in the eyes of national innovation system stakeholders. The political contribution may only consist of making the process official and getting stakeholders involved in carrying out the exercise, but because it is a political "order" the assumption is that the results will be used and the priorities implemented.

Nevertheless, although the process may have been officially ordered by the government, it is still at the mercy of changes in government policy direction. History shows that when a new leader comes into power, this can have an effect on priority-setting (change in the direction of a project, project abandonment, etc.).

Sidebar 6 – Type Two of Political Contribution: The Example of Australia

In January 2001, the Australian government published a major innovation action plan, *Backing Australia's Ability*. This plan stressed the need to adopt a national approach to better target research by focusing on fields where Australia already had (or wanted to have) competitive advantages.

In May 2002, Minister of Education, Science and Training, as well as Minister for Science, announced the Australian government's plan to undertake an extensive exercise in national priority-setting that would apply to and address the entire government. To this end, the prime minister tasked Australia's then chief scientist, Robin Batterham, with this mission.

Once the exercise was completed, Australia released one of the most impressive priority implementation plans of all those discussed in this advisory report. The Australian government first asked government agencies and organizations to produce national priority implementation plans, thereby ensuring that their strategic planning would hinge on the priorities set for all Australian public organizations.

In order to continuously monitor the implementation of priorities, the agencies and organizations also had to produce annual progress reports detailing how national priorities were being incorporated into their respective operations. The government also developed a coordination mechanism based on the roles of four government agencies that also had to produce annual progress reports on the implementation of national priorities. National priorities are also incorporated into all strategic planning activities by Australian universities.

Type three: participation

At this level of involvement, certain decision makers (prime ministers, ministers, heads of organizations, or lead scientists) participate actively in the priority-setting process. Their role varies based on their desired level of participation: they may head the steering committee or serve in an advisory capacity within the methodological process. Political contribution at this level demands more of leaders: in addition to legitimizing the purpose of the exercise, political leaders play an active role throughout the process.

The active participation of the state, which is also the main client of priority-setting exercises, comes with certain risks, such as seeing the priority-setting experience fall prey to partisan politics. This is why there is a tendency to offset the risks with principles of governance, which grant all stakeholders in the project an equal voice and equal weight in the decision-making process.

Sidebar 7 – Third Type of Political Contribution: The Example of Germany

Until 2001, the German government had not had a systematic approach to developing new research, technology, or education projects. Up to that point, priority-setting was a relatively closed shop, and there was limited interaction between the various research institutions, industry stakeholders, and government agencies. Wanting to break with tradition, Edelgard Bulmahn, the minister in charge of this issue at the time, identified the main thrusts of the Futur project herself. She was also behind the "foresight" component of this project.

In the first round of the Futur project, the minister stepped in on a number of occasions to make the final decision on the choice of priorities (lead visions). The decision-making body of Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung - BMBF) also intervened in the second round of the priority-setting process.

Transformation of the priorities selected into research programs or projects was part of the strategic planning for the Futur project from the start. BMBF, which was backed by the project consortium and the sole entity responsible for implementing these priorities, created internal interdisciplinary working groups specifically dedicated to implementing the results of the Futur project. Numerous programs were created after the priorities were set.

BMBF's involvement in this project certainly helped ensure that the results of the priority-setting exercise had an impact on strategic planning at the Ministry.

No matter what their level of commitment, the presence of decision-making authorities throughout the priority-setting process has an impact not only on the implementation of the selected priorities, but also on the motivation of stakeholders throughout the process. However, each type of political contribution raises a certain number of questions, specifically regarding the political motivation behind the priorities selected. This aspect will be discussed in the final chapter of the advisory report.

Observation 5
Major priority-setting exercises tend to take quite specific approaches that draw on a variety of methods but follow a relatively similar logic.

Most priority-setting exercises follow a specific methodological approach, tailored to the needs of the exercise and the type of results sought. As such, there seem to be as many approaches as there are priority-setting exercises. Approaches generally draw on a number of methods borrowed from the fields of social science, management, and mathematics, including:

- Workshops.
- Literature reviews.
- Experts consultations (through a Delphi exercise or another nonforesight method).
- Conferences or special events.

- SWOT[48] analysis.
- Benchmarking or international comparative analysis between countries that use bibliometry and scientometry.
- Surveys or major public consultations.

The unique nature of priority-setting exercises has to do with the numerous methods used at each stage in the exercise and their various possible combinations, which broadens the spectrum of methodological possibilities. However, a closer look at these experiences tends to show how similar they are in terms of operation and logic. The stages of those exercises represent specific steps that can be found in most of the cases studied during the production of this advisory report. Generally, setting priorities involves finding answers to various questions based on the four "typical" phases of a priority-setting exercise. The following table illustrates this idea.

Table 11 — Relationship Between Priority-setting Exercise Methods and Steps

Phase	Sample Questions	Sample Methods
Phase 1 Diagnosis (or overview) of the current situation	• What have we done up to now? • What are our strengths and weaknesses? What can we build on?	• SWOT • Statistical data studies and analyses • Bibliometric analysis
Phase 2 Analysis, selection criteria, and priority-setting process	• What is the state of world knowledge? • What are the emerging fields or fields of the future? • Which priorities are most likely to meet social and economic needs?	• Foresight methods • Workshops • Benchmarking • Public consultations
Phase 3 Decision-making	• What are our priorities?	• Conferences or special events
Phase 4 Implementation and impact analysis	• How can we ensure that NIS stakeholders adopt and implement the priorities? • What kind of followup will there be? • Will we evaluate the exercise?	• Evaluation methods • Monitoring strategies • Development of monitoring and impact indicators

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[48] SWOT analysis (Strengths - Weaknesses - Opportunities - Threats) is a strategic analysis tool. It combines the study of the strengths and weaknesses of an organization, a geographical area, or a sector with the study of the opportunities and threats to its environment. As such, it is instrumental in development strategy formulation. This approach takes into account internal and external factors, with a view to maximizing the potential of strengths and opportunities, while minimizing the impact of weaknesses and threats (European Commission, 2005).

A number of examples can be used to illustrate the complexity and logic of research and innovation priority-setting approaches. That of Japan is particularly telling: its methodology has been proven over time (this is its eighth exercise) and the approach was fashioned on the major trends under way when the exercise was designed.

The methodology of Japan's Eighth Science and Technology Foresight Survey (2003-2004) is divided into four major stages:

1) A public survey on the demand for new technology.
2) A bibliometric study on the quick development of technology.
3) A scenario construction exercise (foresight).
4) A Delphi survey (foresight).

This is a typical example in which the designers chose to use a variety of methods to attain a variety of results. The first stage was aimed at shedding light on the social demand for new technology and involved multiple stakeholders, including civil society. The second stage made it possible to situate technologies already selected based on their current phase of development, through bibliometric analysis of researcher publications. The final two stages used foresight strategies and work by experts to situate the future development of these technologies by the year 2035. In this process, each stage helps orient the next.

Although this is the eighth exercise of its kind, National Institute of Science and Technology Policy (NISTEP) has not replicated the same methodological process eight times over. The experience of each exercise has helped guide the approach for the following one. For example, the eighth exercise is the first to take into account social demand–an issue none of the previous exercises examined.

Observation 6
Exercises often identify priorities on a medium and long-term time perspective, which makes foresight a growing concern in priority-setting.

Examination of the priority-setting exercises conducted in the last 15 years shows that a large number draw on classic foresight methods.[49] Foresight is sometimes even the core approach, with the entire process aimed at a specific target date (e.g., 2015, 2025, 2050, etc.). Recent works produced by Michael Keenan (2005), European Commission (2002), Heide Hackmann (2003), and OECD (2003) have notably confirmed this major trend.

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[49] The notion of "foresight" emerged simultaneously in France and the United States in around 1960. It is a systematic approach for exploring possible futures using its own specific tools and methods. Foresight can be a highly participatory process that involves numerous stakeholders as well as an instrument that guides and clarifies decision-making.

There are four main advantages to the increasing use of foresight in priority-setting.

First advantage:
Provides a long-term overview of a given issue.

Priority-setting may be conducted on a short term basis, with priorities set and applied over the next months or even weeks. But when it comes to developments in science and technology, a broader perspective is often needed to gain a better grasp of how a discipline or technology is developing and to properly assess its economic impact in the relatively distant future. Foresight makes this type of long-term reflection possible through methods that lead individuals to explore the various possible future outcomes of a given situation, discipline, or technology.

Second advantage:
Looks at emerging trends too, not just the essence of our current strengths.

A number of priority-setting exercises are aimed at identifying emerging disciplines or technologies likely to have a major impact on a society's economic development. Their competitiveness in the current socioeconomic context often depends on their ability to play a role in the development of emerging disciplines or technologies with a promising future. There has been a worldwide increase in strategic intelligence initiatives dedicated to studying and anticipating possible developments in scientific and technological knowledge. Foresight and strategic watch tools have been used for decades to this end. In fact, this is one of main reasons they were developed.

Third advantage:
Provides a country with tools to better assess its present and future positioning on the international scene.

As with priority-setting, foresight exercises draw on a number of methods to better identify a country's strengths with regard to major world developments. As such, a number of foresight methods play a key role in the development of a comprehensive international vision.

For a country to assess its own development in a globalizing world, it needs tools comparable to those used in other societies. Since the early 2000s, the international network of foresight experts has grown considerably, and empirical studies on the issue have multiplied. Central to this development is the growing desire and need to create a global community of practice designed specifically to share and compare projects and results from foresight (and often priority-setting) exercises around the world.[50] Thus, the development of foresight methods tends to improve comparative practices and becomes a powerful priority-setting instrument.

Fourth advantage:
Creates a collective intelligence on the process, which fosters the development of shared visions and common objectives.

Though more rigorous and proven, foresight methods are primarily known for their mobilizing effect. Nowadays, foresight is not something one practices alone. As a general rule, foresight exercises tend to bring together a variety of participants, and in recent years this pool of participants has broadened to other kinds of stakeholders: nonprofit organizations, associations, big business, officials, and sometimes even representatives of civil society.

The idea of having a large number of stakeholders is to get the concerned individuals involved so the results are better integrated at the end of the process. Many priority-setting experiences–be they driven by supply (expert opinions on future knowledge developments) or by the demand for new knowledge (identification of the public's needs)–seek to spark deliberations between individuals and to reach a collective consensus.

These four advantages have spurred a number of countries to use foresight in their priority-setting experiences. This is notably the case of Germany (Futur), the United Kingdom (Foresight Programme), Japan (Science and Technology Foresight Survey), the Czech Republic (Technology Foresight 2002), Ireland (Technology Foresight Ireland) and France (Key Technologies 2000, 2005, 2010).

Various other priority-setting exercises, although they do not rely solely on foresight, use the results of recognized foresight studies as food for thought in their reflection on the future of science and technology development. This is notably the case of Spain, which instead opted to use foresight studies previously conducted by Industry and Technology Foresight Observatory (Observatorio de Prospectiva Tecnológica Industria) to guide and stimulate its reflections on national research priorities.

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[50] The European Foresight Monitoring Network (EFMN) has been developing considerable know-how in the last three years on foresight methods and on how and why they are used. It produces mapping reports that detail the extent to which foresight studies are used in Europe and around the world. Page 18 of the *2007 Global Foresight Outlook* report, which is available at the following address, discusses the most commonly used methods in the foresight studies surveyed by EFMN: http://www.foresight-network.eu/files/reports/efmn_mapping_2007.pdf.

Although foresight is gaining popularity, not all countries use it in their priority-setting initiatives. Australia and Denmark, in particular, have opted for other approaches that have proven just as successful. But the increasing importance of medium and long-term projections in actual priority-setting, as well as the tendency of certain countries to adopt policies and strategies that develop over a long time horizon,[51] suggests growing interest in foresight in the years to come.

Observation 7

Priority-selection criteria are usually based on the notions of attractiveness and feasibility.

When priorities are selected, a certain number of criteria must be defined in order to choose between various possibilities. These criteria are important, because they provide the main justification for choosing one priority over another. Over time, certain countries or organizations have developed more complex models enabling them to define selection criteria in a few major categories. The most famous example is undoubtedly that of Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), a government organization that has used this approach in numerous priority-setting exercises over the years.

Table 12 — Some Factors used to define Attractiveness and Feasibility Criteria

Criteria	Examples
Attractiveness	• Potential impacts on quality of life, society, the environment, and public welfare • Potential impacts on the economic development of a country or a region, its wealth, its pool of private businesses, and its international competitiveness • Potential impacts on the programs and organizations already in place, intergovernmental cooperation, and a country's position on the international scene
Feasibility	• Availability of human resources • Sufficient degree of scientific and technological development to conduct research and development work on the priority • Public receptiveness to the priority (ethics, perceptions, buy-in, etc.)

This model was first developed by U.S. Industrial Research Institute, but became better known when CSIRO successfully implemented it in the early 1990s. It was then picked up by other countries, including New Zealand in 1995.

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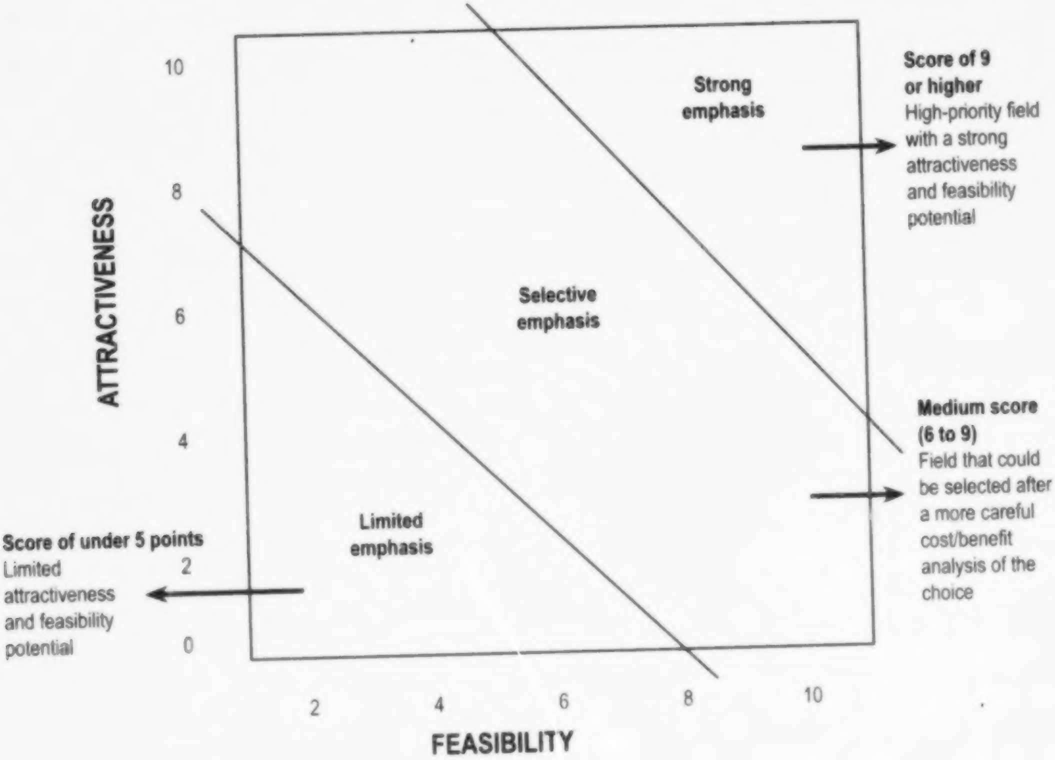
[51] This is notably the case of the United Kingdom (Science & Innovation Investment Framework 2004–2014) and China (National Guidelines of the Medium and Long-term Science and Technology Development Program, 2006–2020).

CSIRO's evaluation framework is based on estimating the attractiveness (or potential benefits) and feasibility (or potential success) of the selected thematic priority, be it technological, social, or scientific. A sector's attractiveness is determined based on the potential benefits it represents and the likelihood that an organization or country will be able to generate them. Feasibility is determined based on criteria of R&D potential and R&D capacity (researchers and facilities). Attractiveness and feasibility estimates are generated using number scores attributed to each priority field based on the attractiveness and feasibility criteria. They are then transposed graphically (as illustrated in Figure 1) to help guide decision makers' choices.

Figure 1 – Diagram of Feasibility and Attractiveness Criteria Score Distribution, as Used by the Alberta Science and Research Authority (ASRA) in 1996



Score of 9 or higher
High-priority field with a strong attractiveness and feasibility potential

Medium score (6 to 9)
Field that could be selected after a more careful cost/benefit analysis of the choice

Score of under 5 points
Limited attractiveness and feasibility potential

Over time the CSIRO model was reused and remodeled according to the needs of various priority-setting exercises. While the model has always followed the basic "attractiveness / feasibility" logic, subcategories or other subdivisions have also been added. This was notably the case in the first round of the Foresight Programme in the United Kingdom (1994).

In 2002 the Czech Republic also used the main criteria categories. The following table, which presents this country's priority-selection criteria, covers most of the main categories commonly used in the priority-setting exercises examined in this advisory report.

Table 13 – Selection Criteria in the Czech Republic Priority-setting Exercise (2001)

Attractiveness[52]				Feasibility	
Economic, Social, and Environmental Importance			**Research and Technological Opportunities**	**Application Potential**	**Research and Technology Potential**
Economic Importance	**Social Importance**	**Environmental Importance**			
Importance for GDP growth	Importance for human health	Impact on material effectiveness	Potential to create new technologies	Competitiveness of the application sector(s)	Current state of the art of the research field
Importance for exports	Importance for the safety of society	Impact on energy effectiveness	Probability of "breakthrough" discoveries	Measures, public policies, and regulations that benefit the target sector	Probability of positive developments in this field of research
Impact on productivity	Impact/ influence on quality of life	Positive impact on the environment	Probability of creating new applications	Availability of world research results in field	Availability of necessary R&D infrastructure
Market size	Influence on job creation	Potential of replacing nonrenewable energy sources with renewable ones	Possibility of combining the research with other research fields (multidisciplinary partnerships)	Market demand for the application sector	Financial requirements of the research direction
Strategic importance for the Czech Republic internationally		Natural and productive space-saving effect	Possibility of implementing the research results in other applications or technologies	Impact on the creation and growth potential of SMEs	Probability of financing from various sources
		Effects on transportation requirements	Probability of joint research with other fields (e.g., bioinformatics)		Level of education required in related fields
			Probability of involvement in international R&D partnerships in the target field		Current quality of human resources in the field
			Probability of meeting society's research needs in the priority field		

Source: Karel Klusacek, for the United Nations Industrial Development Organization (UNIDO).

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[52] In this exercise, the Czech Republic opted to use the notion of importance, which has roughly the same meaning as "attractiveness" in this context.

Exploring the selection criteria for priority-setting exercises often gives a better understanding of current concerns in the country or region commissioning the exercise; priority-selection criteria often reveal national or regional particularities. For example, in the priority-setting exercise the United States conducted in 1995, it selected two major criteria categories: economic prosperity and national security. The latter category was divided into three subcriteria specifically related to the development of military technology.

Observation 8
The seeming convergence of national thematic priorities around the world does not rule out a higher level of diversity within each country.

Certain authors and stakeholders question the relevance of conducting major priority-setting exercises, asserting that all such exercises always lead to the same thematic priorities. By adopting a very broad vision (i.e., grouping various priorities by the main categories they belong to), it can indeed be noted that the main fields selected in priority-setting exercises correspond to the popular themes of the last ten years. Conseil de la science et de la technologie tested this by analyzing and categorizing 380 priorities taken from 21 priority-setting exercises of all kinds conducted in the last 15 years.[53]

This analysis revealed six major priority fields for over 20 countries around the world:

- Advanced technologies (ICT, materials, nanotechnology, instrumentation, control technologies, machinery and processes, biotechnology).
- Health/health sciences and technologies.
- Environmental protection and sustainable development.
- Natural resources.
- Energy.
- Transportation /mobility /infrastructures.

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[53] The tables of this compilation, produced by Geneviève Drolet and Richard Blanchette of CST, may be consulted in appendices 3 and 4 of this advisory report. However, when interpreting the results of this table, it is important to keep in mind that this classification work is exploratory.

These broad themes raised in the priority-setting exercises discussed in this report are similar to the themes that emerged from a study conducted by University of Sussex Science and Technology Policy Research (SPRU) group in 2002.[54] This paper, commissioned by International Council for Science (ICSU), explored the key emerging themes in science and technology. To this effect, the experts selected a number of national foresight exercises conducted between 1995 and 2002 by 32 countries and five international organizations.

Information and communication technologies are still the biggest priority subfield in all priority-setting exercises. Other advanced technologies, such as nanotechnology, biotechnology, and new materials, round out the list, illustrating a certain concern for convergent technologies, which many view as the driving force of tomorrow's economy.

The study of thematic priorities also shows the growing popularity of priority-setting exercises that identify socioeconomic topics. In producing this brief, we identified over 62 such priorities in the exercises examined–the second most widely cited group of priorities. These were mainly major issues such as demographic change, globalization, or innovation (innovation culture, innovation system, etc.).

However, when taking a closer look at recent priority-setting findings, it is clear that the priorities are numerous and the detail involved varies from one exercise to the next.

A priority's level of detail is in part dependant on the type of priority-setting exercise used: a technological priority is much more detailed and specific than a priority from a "social problem resolution" priority-setting exercise. The level of detail is also specific to each exercise and each priority-setting method.

The following example presents three priorities (from three different priority-setting exercises) that come from the same "family," but are expressed with different levels of detail.

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[54] The full report of this study may be consulted at http://www.icsu.org/2_resourcecentre/Resource.php4?rub=6&id=14.

Table 14 – Example Illustrating Three Levels of Detail in Priority Selection

High Level of Detail	Moderate Level of Detail	Low Level of Detail
Belgium Regional Technology Foresight Flanders 2015	Alberta, Canada R&D Priority Setting Consultation: Guidance toward an R&D Strategy for Alberta	European Union (IPTS) Emerging Thematic Priorities for European Research
Biomolecular diagnosis and biomarkers	Biotechnology	Health science and technology

Although certain major priorities systematically emerge from one priority-setting exercise to the next, some dissimilar priorities do appear through the reflections of each priority-setting experience. These priorities correspond to national specificities and often contain a strong cultural dimension. The reasons for selecting priority themes, such as "art and culture," "telework," or "national security" attest to the importance certain societies or organizations attribute to these issues.

Observation 9

The impact a priority-setting exercise has is contingent not only on the results it yields (list of priorities), but particularly on the manner in which the priority-setting process is designed and carried out as a whole.

Being able to determine the impacts a priority-setting exercise has makes it possible to understand how the selected priorities have transformed into concrete measures, programs, or initiatives. The impacts are also perceived as being a tangible, and sometimes measurable, benefit of priority-setting exercises–and therefore a way to justify and show that the costs and effort invested in priority-setting were profitable.

Examination of the priority-setting exercises conducted in the last fifteen years reveals that the extent of impacts can be observed from either a short or long-term perspective. **Short term** impacts are generally relatively tangible and show the direct effects on current R&D management and the various national innovation system stakeholders. For example, priority-setting has a direct impact on:

- The amount and breakdown of R&D budgets.
- The strategic planning of government research bodies and other NIS stakeholders.
- Company business and R&D strategies.
- The creation of new research programs in priority fields.

- The creation of new R&D organizations.
- The implementation of new NIS monitoring and analysis strategies.
- Stakeholder involvement (research networks, partnerships, international R&D cooperation, etc.).
- How R&D is organized (interdisciplinarity, multidisciplinarity, stakeholder participation in decision-making, etc.).

The **longer term** impacts of priority-setting exercises are sometimes less tangible. They often deal with social, economic, or cultural changes that influence the ways people view innovation. They may include:

- The ongoing structuring of research around priority themes.
- Stronger innovation networks.
- International repute in priority fields.
- Increased development of novel, sustainable solutions to identified social problems.
- The development of skilled human resources in critical sectors.

Short term impacts are often quantifiable and fairly easy to observe a few years after the priorities are implemented. Longer term impacts are often indirect or found in combination with other factors, which makes it harder to measure their size or scope. However, the most effective priority-setting exercises are also those that make priority implementation a full-fledged step of the methodological approach.

Sidebar 8 – The Australian National Research Priority-implementation Process

The Australian example shows great concern for priority implementation. This concern first emerged when stakeholders and citizens consulted on the priority-setting process voiced their desire to see the process pay particular attention to how priorities are implemented. The priority-setting exercise was therefore designed so that the implementation of national research priorities would be visible in the various action plans and strategies of all public organizations, agencies, and ministries involved with research and innovation. This is also the case for Australian universities.

Australia used three main mechanisms to incorporate national priorities into the planning of various Australian agencies:

- **Implementation plans**

  The Australian government asked all government R&D agencies and organizations to produce national priority-implementation plans informing the authorities how these priorities would be incorporated into their respective strategic planning activities. These plans were checked and approved by Australia's chief scientist, backed by a panel of government-commissioned experts.

Sidebar 8 (suite)

- **Progress reports**

  In order to continuously monitor the implementation of priorities, agencies and organizations also had to produce annual progress reports detailing how national priorities were being incorporated into their respective operations. Each public agency or organization involved in R&D activities therefore issued progress reports in 2004, 2005, and 2006.

- **Coordination**

  The Australian government set up a coordination mechanism backed by four government agencies. This committee was responsible for harmonizing national priorities with the various missions of ministries as well as organizations of a more sectoral nature.

In 2005 Australia also created the National Research Priorities Standing Committee, which was tasked with evaluating the progress of national-priority implementation and reporting its findings to the government. The first of these reports, which are periodically incorporated into the country's national research strategy evaluation report, was published in May 2007.

The Australian government primarily looked at the budget process and the development of priority-implementation mechanisms to create an impact on the entire Australian research system. This method is a good example, but is not the only way to ensure that priority-setting exercises and their results have a certain impact.

The impacts of a priority-setting exercise usually come to light when officially measured and studied a few months or years after the priorities have been set. In recent years, various expert studies, and particularly evaluations of priority-setting exercises, have revealed numerous factors that affect the success and impact of the priority-implementation stage. In a presentation given at an international seminar on science and technology priority-setting (Montréal, June 2, 2008),[55] Michael Keenan highlighted certain factors that help increase the impact of priority-setting exercises:

- Endeavoring to perceive and comprehend the priority-setting exercise based on the added value it will bring to each stage of the experience and the strategic intelligence it is likely to create throughout the process instead of the results (list of priorities) it will generate.
- Paying close attention to the priority-setting process: Beyond the results, the process itself is often a considerable source of impacts.
- Endeavoring to generate informative and targeted outcomes based on the target clientele.
- Creating a communication strategy specifically designed to publicize the results of the priority-setting exercise.
- Incorporating a priority-implementation phase into the actual priority-setting process.

Most experts say it is critical not to bank on the potential impacts of the exercise, because every step of the process is conducive to achieving specific objectives and results.

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[55] See Appendix 1 for more information on this event.

Observation 10

Evaluating priority-setting exercises helps provide a better understanding of the tangible and intangible impacts of the exercise, while improving the priority-setting practices of a society or organization.

The need for evaluations is a growing concern in many countries around the world, and priority-setting exercises are no exception. Because it is so difficult to set up quantitative indicators to measure the impact of priorities on the national innovation system, there is a tendency to turn to other forms of evaluation that are more qualitative and more centered on the process. In the last ten years or so, a number of priority-setting exercises have been evaluated, particularly first-time national exercises.

Sidebar 9 – A Few Evaluations of Priority-setting Exercises

- Germany – Futur. The German Research Dialogue (2001-2005)
- Australia – National Research Priorities (2002)
- Hungary – Hungarian Technology Foresight Programme (1997-2000)
- Ireland – Technology Foresight Ireland (1997-1999)
- Japan – Science and Technology Foresight Survey (1970-...)
- Czech Republic – Technology Foresight 2002 (2001-2002)
- United Kingdom – Foresight Programme (1994-1999

Luke Georghiou and Michael Keenan[56] maintain that there are three motivations that prompt designers of priority-setting exercises to evaluate the experience and its spinoffs:

1. Accountability

To determine the process's effectiveness from a return-on-investment standpoint (proper use of public funds).

2. Justification

To determine whether the effects and impact of the priority-setting process justify its continuation and extension.

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[56] Luke Georghiou and Michael Keenan produced this text by analyzing foresight exercise evaluations. Since these exercises often also do double duty as research and innovation priority-setting exercises, the same characteristics fully apply to both.

L. Georghiou and M. Keenan (2004), "Towards a Typology for Evaluating Foresight Exercises." In EU-US *Seminar: New Technology Foresight, Forecasting & Assessment Methods-Seville, May 13-14, 2004*, http://forera.jrc.ec.europa.eu/fta/papers/Session%204%20What%27s%20the%20Use/Towards%20a%20Typology%20for%20Evaluating%20Foresight%20Exercises.pdf.

3. Learning

To determine the best methods to use under similar circumstances (exemplary practices, things that worked and should be tried again, etc.).

Evaluation of priority-setting exercises, for which there are thus three motivations, may be conducted 1) by outside experts from a variety of backgrounds who did not help develop or conduct the exercise or 2) by officials of the country or organization in charge of the project.

As a general rule, evaluation seeks to answer the following questions:

- Did the project achieve its objectives?
- How effective were the various methods used, how well did they work, and what was their interaction with other methods and tools?
- What was the overall process like (how did it take place)?
- What were the results (impact of identified priorities on major public research programs)?

In most of the exercises evaluated, evaluation committee members needed the help of those involved in the priority-setting exercise. Participants were invited to fill out surveys to give their impressions of the project or answer evaluator questions. According to Georghiou and Keenan, three types of criteria are typically used to evaluate a priority-setting exercise.

First type of criteria: Appropriateness of the process

This type of criteria mainly looks at the rationale and arguments for the exercise, which makes it possible to contextualize the priority-setting exercise based on its objectives. These criteria allow evaluators to question the very rationale for the priority-setting process based on the organization's needs and formulate the necessary arguments for or against the exercise.

Second type of criteria: Efficiency of the process

This type of criteria primarily deals with the logistical and managerial issues of the process. It answers questions that may concern, for example, the stakeholders involved in the process, the support provided to expert groups, the relationship between the priority-setting exercise and decision makers, and any questions related to the methods used.

Third type of criteria: Impact and results

This type of criteria mainly focuses on the results, whether tangible (the priorities themselves, changes made to R&D financing, etc.) or intangible (effects of the priority-setting process). To this effect, Keenan and Georghiou note the tendency of most leaders to evaluate only the results (outputs), which disregards the significance of the priority-setting process, and thus the intangible contributions of the exercise (outcomes).

As mentioned in Chapter 2 of this report, the intangible contributions of a priority-setting exercise are often what provide the greatest benefits (they mobilize stakeholders, create networks, stimulate and create common and consensual strategic intelligence, etc.). These outcomes, which are often difficult to measure, are the impetus behind many of the priority-setting exercises conducted in recent years.

Sidebar 10 – Example of a Priority-setting Exercise Evaluation: Germany's Futur Project

Futur. The German Research Dialogue was a priority-setting exercise by Germany's federal education and research ministry (BMBF) that looked at the social demand for new knowledge. This project, which was conducted from 2001 to 2005, was evaluated at the end of its first phase by a group of international experts directed by Luke Georghiou of PREST, in the United Kingdom.

The evaluation of Futur had to answer six major questions:

- Were the project objectives reasonable?
- Were the project objectives met?
- Were the stages of the methodological process appropriate for meeting the project objectives?
- Did the methodological process generally lay the foundation for the goals and objectives to be met?
- What could be done to improve the odds of meeting the desired objectives?
- Were the tools and methods applied effective and efficient at meeting the initial objectives?

As part of their task, evaluators focused on three themes: stakeholder participation, the priority-setting process, and implementation of the selected priorities. The evaluation, which included multiple steps, took a full year to complete and required the consultation of a number of stakeholders involved in the process (participants, the ministry responsible for the project, the contracting parties, and the consortium in charge of running the operation).

Generally, the following main conclusions drawn by the evaluator group helped improve subsequent phases of the project:

- Phase I of Futur fulfilled its main objectives of stimulating participation and generating interdisciplinary priorities that were based on social demand.
- Greater representation of industry and private business was needed among participants in a later phase (which raised the issue of encouraging participation-remuneration, for example).
- Co-nomination of participants should have been monitored better and backed by other selection methods in order to ensure maximum representativeness.
- The consortium needed to take greater measures to ensure that special interest groups (and certain researcher communities) did not have too big an impact on the focus of discussions and the selection of priorities.
- The methodology needed to be less complex to avoid potential redundancies in certain steps, and to increase the transparency of the process.
- A dedicated budget needed to be allocated to priority implementation in order to increase the potential impact of priorities.
- Other ministries and political stakeholders needed to take part in a later phase (if the topics were likely to interest them) in order to heighten the project's impact on German public policies.

After the first evaluation, BMBF leaders decided to undertake a second and third phase of the Futur project.

Prerequisites to Successful Priority-setting

The ten observations above provide greater insight on how priority-setting exercises work, their value, and the various key points for making them work. The following findings are drawn for the most part from analysis of recent international experiences:

- Priority-setting is a complex activity that requires familiarity with its practical and theoretical intricacies in order to ensure success.
- Priority-setting is not a random activity to be undertaken without reference points or markers; it must be based on the collective reflection of concerned and committed stakeholders and must be directed by a group that can lend it the legitimacy needed to create an impact.
- Despite the apparent heterogeneity of the experiences–due to their variety and unique approaches–there are certain constants and principles that can help improve practices over time.

International experience is rich and abundant, but difficult to fully transpose from one country to the next. The designers of more recent priority-setting exercises have instead sought to draw selectively from it to build their own unique approach. Certain prerequisites to successful priority-setting are identifiable from international experiences.

1. Recognize the need to set priorities

Priority-setting exercises can only be conducted if they enjoy the broadest possible consensus among concerned stakeholders about the need and purpose of the exercise. Such a consensus is also critical with regard to the objectives of the exercise and the advantages the priority-setting experience will yield for the development and improvement of the national innovation system.

2. Secure government support

Since government bodies are major stakeholders in the priority-setting process, this type of exercise cannot be conducted without the contribution of the ministries and organizations concerned. Their contribution must legitimize the process and thus make it easier for stakeholders to recognize this legitimacy.

3. Stress rigor and transparency

The rigor of the process tends to ensure its credibility with international experts, and above all with the stakeholders involved in it. However, this rigor must go hand in hand with a concern for transparency at every step of the methodological process. The rigor of the process can only be fully borne out if the process is transparent and the various stakeholders and the public are adequately informed.

4. Keep the lines of communication open for the duration of the exercise

The concern for transparency therefore requires that the lines of communications remain open throughout the priority-setting process in order to keep stakeholders and the public informed of the progress and achievements made. Effective communication leads to a feeling of belonging, which is an important benefit that fosters integration of both the priority-setting experience and the priorities set.

5. Conduct the exercise in an international perspective

One of the biggest benefits of priority-setting is that it helps a country or region identify its strengths and assets, and thus situate itself in the global arena. In order to maximize the priority-setting exercise's impact, it is important to be able to maintain this international (and comparative) perspective throughout the process, which will notably be reflected in the participants and methods selected as part of the overall approach.

6. Put in place a realistic management framework to see the project through

Priority-setting exercises can take a long time and require the sustained efforts of numerous stakeholders. They generally monopolize part of the resources of the organization(s) responsible for them. Most of the priority-setting exercises discussed in this advisory report took at least one year, with those with more than one phase in their methodological process sometimes even taking two or three years.

Sidebar 11 – Duration and Cost of Some Priority-setting Exercises

- Japan's Eighth Science and Technology Foresight Survey took one year (2003-2004) and cost some €650,000 (or about $1 million).
- The first round of the United Kingdom's Foresight Programme took five years (1994-1999). The initial budget was £1 million (or about $1.9 million). However, budgetary adjustments had to be made during the process to make it possible to successfully complete all stages of the project.
- The Belgian project Prométhée 1, which lasted two years, required a total investment of €499,500 (or some $770,000), financed in part by European Commission and the Walloon region.
- The Hungarian Technology Foresight Programme, which took three years (1997-2000) and required an investment of €800,000 (or some $1.2 million), was fully financed by National Committee for Technological Development.

Having the means to successfully complete every stage of the project and bring it to fruition is critical in any priority-setting project. To do so, it is necessary to define an applicable implementation strategy, while taking care to ensure that the methods chosen reflect the means available (financial and human resources) and that the various phases and steps are scheduled carefully.

The observations on priority-setting, as well as the prerequisites to successful priority-setting discussed in this chapter, should help define a Québec approach to priority-setting that draws on the practical and theoretical expertise developed elsewhere in the world. To this end, it is important first to examine the role priority-setting has played thus far in the fields of research and innovation in Québec. What experiences can we draw on? But most importantly, what characteristics specific tô Québec are likely to influence the development of a Québec approach to priority-setting? Our strengths and specific context will set the stage for the measures we must take to optimize how we set collective priorities shared by stakeholders.

Chapter 4
Setting Research and Innovation Priorities for Québec

4.1 Setting Priorities in Research and Innovation Policy Development

Any quick look at Québec government policy and strategy documents on research and innovation from the past three decades shows a near constant concern for setting priorities. There has been a general recognition of the need to do so, and answers have been sought on how best to do so. As for the priorities themselves, they have mostly been functional in nature, but also frequently thematic or sectoral.

Many Québec innovation system stakeholders have also undertaken at various times to set their own priorities—with an increasing eye to main international trends in the field—and have sought out the means to do so.

This wealth of experience can now be used to enhance today's approach to priority-setting in research and innovation in Québec. The current trend is toward heightened use of more systemic, recurring, and collective processes. Québec already has most of the tools and know-how it needs to take advantage of these new approaches.

This chapter takes a look back at past actions and reflection in Québec on priority-setting. After this historical review, it examines the federal context and how it has influenced priorities in Québec, then considers individual experiences of certain players in the Québec innovation system.

From this review of Québec's experience, the chapter will conclude with a certain number of key observations to aid Conseil de la science et de la technologie in formulating its recommendations in the following chapter.

Historical Review

The early seventies saw the emergence of the first government science policy initiatives. It was a time of accelerated scientific and technological development, driven mostly by major investment in research fields where Québec had already made a name for itself, such as biomedicine, as well as in big engineering projects such as hydroelectrical production and distribution.

In **1971**, Comité ministériel des politiques scientifiques du Québec (Québec's Ministerial Committee on Science Policy) stated that research policy must "reflect social and economic needs, set out in a list of fields of interest."[57] The focus was on those who would use the knowledge generated by research. The need to identify priorities was noted, but there was no actual mention of how this was to be done.

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[57] Comité des politiques scientifiques du Québec (Science Policy Committees of Québec - 1971), *Les principes de la politique scientifique du Québec* (Science Policy Principles in Québec).

In **1972-1973**, Conseil de la politique scientifique du Québec (Québec's Science Policy Council), a new body created at the recommendation of the ministerial committee, suggested that part of Québec's scientific and technological development be in the form of targeted actions and joint initiatives. It drew up an initial list of priority sectors (laser technology, oceanography, thermofusion, wood technology) and approached a variety of organizations on working together on specially identified priority themes.

Between **1976** and **1991**, Québec entered a period noted for its focus on broad functional priorities: scientific development at first (1976-82), followed by technological development (1982-91). This was a time of increasing government action in research and innovation and the proliferation of stakeholders who would form today's national innovation system.

Initial reflections on the form that Québec's first-ever science policy should take pointed out that choices would have to be made, given the limited resources. Thus research priorities in academic, government, and industrial fields were one of the main points of discussion in the green paper *Pour une politique québécoise de la recherche scientifique* (For a Québec Scientific Research Policy) released in **1979**. Even though the paper made no mention of which scientific fields should enjoy the benefit of added resources, it stressed the need to "develop conditions and mechanisms for arriving at such decisions.[58]"

In **1980** the white paper *Un projet collectif* (A Collective Project), inspired by the consultations that had led to the green paper, reiterated the importance of priority-setting. It further suggested that priorities be determined democratically and with the specific involvement of the scientific community. Priority-setting would thus "actively contribute to the cultural and social development of Québec society as well as to its economic growth and the quality of life of its citizens.[59]" This marked a first reflection on what approach to take to priority-setting, based on three different scenarios.

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[58] P. Beaulieu and D. Bertrand [dir.] (1999), *L'État québécois et les universités. Acteurs et enjeux* (Québec and Its Universities. Actors and Issues), Québec City, Presses de l'Université du Québec, pp. 75-76.

[59] *Ibid.*

Sidebar 12 – Possible Approaches to Determining Research Priorities According to the White Paper *Un projet collectif* (A Collective Project - 1980)

First scenario – Combine a policy statement with certain specific scientific research actions. This is a process used in special cases when urgent needs are in danger of not being met in a timely fashion, particularly in research fields where Québec is not sufficiently present, but has future needs. The state, after consulting on the matter and assessing needs, takes certain foundational actions on its own initiative, e.g., promoting the emergence of new core groups of researchers by providing them with facilities to work in and the financial backing they require.

Second scenario – The state undertakes to identify priority research fields for Québec's development. In addition to proposing general development objectives, the state identifies certain scientific development priorities that it is willing to promote through special support and assistance programs. These priorities are identified with the aid of various advisory bodies through a process that includes dialogue with the scientific community.

Third scenario – The state asks the scientific community to align its research priorities with overall social, political, and economic development priorities. This priority-setting process is primarily founded on a sharing of responsibilities as well as on a mechanism of dialogue between researchers and representatives of the state. The government designs research funding mechanisms that will enable the scientific community to align itself with the social, economic, and political priorities of the state.

In the first half of the eighties, the Government of Québec sought to emphasize Québec's technological development by focusing its efforts on big industrial projects. This led from **1986** to a split between science and technology in ministry missions for some years.

In **1982**, phase 2 of the economic action program *Bâtir le Québec, Le virage technologique* (The Technology Conversion. Challenges for Quebec Phase 2, A program for Economic Action) targeted several industrial sectors that Québec held to be key. The importance of having "industrial priorities that reflect evolving domestic and international demand and that build on past achievements, i.e., Québec's production factors and comparative strengths[60]" was duly noted, along with the importance of the primary sector to Québec's economic development. However, the government's main wish was to stress technological development in major industrial sectors (aerospace, shipbuilding, public transportation) and to boost emerging technologies (electronics, ICT, biotechnology). The program also identified several broad functional priorities, including spurring innovation and industrial research.

Inspired by this program of action, ministère de la Science et de la Technologie (Science and Technology Ministry), created in **1983**, set several industrial priorities aimed at modernizing traditional sectors while fostering the development of new technologies (informatics, microelectronics, biotechnology). It was about this time in **1984** that CST–the successor to the Science Policy Council–released its advisory report on the technology revolution (*Avis sur le virage technologique*) stressing the need to identify areas for priority action in Québec.

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[60] Gouvernement du Québec (1982), *Le virage technologique : programme d'action économique 1982-1986. Bâtir le Québec - Phase 2* (The Technology Revolution: 1982-86 Economic Action Program, Building Québec - Phase 2), Québec City, p. 24.

This need was borne out at the Technology Summit in **1988**, which brought business, academia, and government together to discuss guiding ideas and the priorities to which technology challenges give rise. Priority-setting was part of the discussions, notably because participants had noted that "a piecemeal approach of providing financial stimulus in a broad array of sectors considerably reduces the ultimate impact.[61]" Participants therefore concluded from their deliberations that three things were needed to spur technological development in Québec: 1) a focus on sectors where Québec possessed a distinct advantage, 2) a better balance between technological development and basic research, and 3) a substantial boost in R&D resources.[62]

The same year Québec released a new action plan called *La maîtrise de notre avenir technologique. Un défi à relever* (Meeting the Challenge of Our Technology Future), drawn up in preparation for the Technology Summit. The plan acknowledged "the need to step up efforts in technology fields where Québec can meet with international success, in order to remain competitive and to create or save the jobs of tomorrow.[63]" It was a three-part strategy that was in actual fact three broad functional priorities: 1) support for R&D investment and high tech entrepreneurship, 2) technology transfer and development, and 3) coordination of stakeholders and the strengthening of international cooperation in technology fields. The action plan led to the creation of the Technology Development Fund that "although it does not set priorities [...] encourages universities to take the lead in their fields of excellence by joining with private enterprise and suggesting projects.[64]"

Broad functional priorities were still the focus in the nineties, but government action turned more and more to the concept of "industrial clusters."

In **September 1992**, ministère de l'Industrie, du Commerce et de la Technologie (Ministry of Industry, Trade, and Technology - MICT) published *La stratégie industrielle du gouvernement du Québec : retrospective et perspectives* (The Industrial Strategy of the Government of Québec: From Yesterday to Tomorrow), which took an analytical approach to identifying and targeting industrial sectors in need of development. The strategy, which was largely inspired by the work of Michael Porter[65], urged the development of industrial clusters in order to "build sectors of activity able to foster the development of international caliber firms that draw on networks of subcontractors and drive small business development in all regions of Québec.[66]"

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[61] Gouvernement du Québec (1988), *Sommet québécois de la technologie. Compte rendu des délibérations* (Québec Technology Summary Deliberations. Thematic summary of main points raised in workshops), Montréal, The Summit, p. 8.

[62] *Ibid.*, p. 5.

[63] Gouvernement du Québec (1988), *La maîtrise de notre avenir technologique. Un défi à relever* (Meeting the Challenge of Our Technology Future), Québec City, Ministère du Commerce extérieur et du Développement technologique (Ministry of Foreign Trade and Technological Development), p. 67.

[64] P. Beaulieu and D. Bertrand [dir.] (1999), *op. cit.*, p. 83.

Table 15 – The 13 Industrial Clusters Selected by MICT in 1992

Competitive Clusters	Strategic Clusters
Areas where Québec was already somewhat competitive	**Areas whose development potential it was crucial to develop**
• Aerospace • Pharmaceuticals • Information technology • Electrical energy production, transportation, and distribution equipment • Metal and mineral processing	• Ground transportation • Petrochemicals and plastics processing • Bio-foods • Housing and construction • Fashion and textiles • Forest products • Environment • Cultural industries

This strategy would lead to the creation of sectoral issue tables.

The same year, ministère de l'Enseignement supérieur et de la Science (Ministry of Higher Education and Science - MESS) published a discussion paper entitled *Le développement scientifique au Québec* (Scientific Development in Québec). It noted that "it is becoming more and more important to select scientific priorities, but harder to do so given that expectations are growing faster than the means and resources available.[67]" It claimed the difficulty stemmed from the fact that "strategic choices are not any more obvious or easy with the progress of science, but rather more complex, more urgent, and less obvious.[68]" MESS thus concluded that for Québec to develop scientifically and technologically it had to strive for excellence, and that given the province's scarcity of resources and its fast-growing needs, research priorities had to be set for this to happen.

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[65] M. Porter (1990), *The Competitive Advantage of Nations*, New York, Free Press.

[66] Ministère de l'Industrie, du Commerce et de la Technologie (1992), *La stratégie industrielle du gouvernement du Québec : rétrospective et perspectives* (The Industrial Strategy of the Government of Québec: From Yesterday to Tomorrow), Québec City, Ministère de l'Industrie, du Commerce et de la Technologie (Ministry of Industry, Trade and Technology), p. 16.

[67] Gouvernement du Québec (1992), *Le développement scientifique au Québec* (Scientific Development in Québec), Québec City, Ministère de l'Enseignement supérieur et de la Science (Ministry of Higher Eduction and Science), p. 47.

[68] *Ibid.*

Following the release of these documents, the government asked CST to identify scientific priorities, which led to the drafting of an advisory report entitled Urgence technologie. *Pour un Québec audacieux, compétitif et prospère* (Emergency Technology: For a Bold, Competitive and Prosperous Québec). Published in **1993**, this brief had a different focus–the dynamics of technology–and targeted four broad functional priorities. It also addressed the question of strategic research in Québec, calling notably on universities to focus their energies "in areas of specialty that align with their strengths and vision" in order to develop critical masses of researchers able to compete internationally. This marked CST's first call for collaboration and consensus in identifying sectoral research priorities.

In **1999** in response to a request from the minister responsible for industry and commerce, CST published *Intensifier l'innovation : les orientations prioritaires* (Towards a Québec Innovation Policy: Strengthening Innovation: the Priorities) in which it suggested three broad functional priorities for a Québec innovation policy. This advisory report was part of series aimed at aiding development of a future Québec Science and Innovation Policy. In all, nine reports set out the current state of affairs in various problem areas associated with the three spheres of the "national innovation system" that CST was then beginning to promote. Once again, the entire focus was on broad functional priorities, with no mention of how to determine thematic priorities of whatsoever nature.

In **2001**, the Government of Québec released a Québec science and innovation policy (QSIP) entitled *Savoir changer le monde* (Knowledge to Change the World: Québec Policy on Science and Innovation). This substantial work identified several functional priorities intended to ensure the well-being of Québec society and maintain and develop its economic prosperity. Without explaining how these priorities had been identified, the policy resurrected the idea of thematic priorities, naming several leading-edge industrial sectors (aerospace, pharmaceuticals, ICT, and energy), economic sectors undergoing expansion (optics, multimedia, the environment, etc.), as well as several economic sectors that were already well established.

In its policy, the Québec government again acknowledged the strategic importance of monitoring and foresight, "which will play a key role in the ongoing policy update process.[69]"

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[69] Gouvernement du Québec (2001), *Savoir changer le monde. Politique québécoise de la science et de l'innovation* (Changing the World: Québec Science and Innovation Policy), Québec City, Ministère de la Recherche, de la Science et de la Technologie (Ministry of Research, Science, and Technology), http://www.mdeie.gouv.qc.ca/index.php?id=190&tx_ttnews%5BcurrentCatUid%5D=80&tx_ttnews%5Btt_news%5D=1151&tx_ttnews%5BbackPid%5D=177&cHash=e1899d793a.

The work on the most recent Québec Research and Innovation Strategy (QRIS), *Un Québec innovant et prospère* (An Innovative, Prosperous Québec. Québec Research and Innovation Strategy), was mostly guided by the recommendations of Conseil des partenaires de l'innovation (Innovation Partners Council), which carried out its priority-setting mandate by identifying a number of functional priorities.

Sidebar 13 – What is Conseil des partenaires de l'innovation (Innovation Partners Council)?

Conseil des partenaires de l'innovation was a temporary advisory body chaired by the minister responsible for research and made up of 23 members from academia, industry, and government. Its task was to advise the minister of economic development, innovation, and export trade on matters of science and innovation, particularly with regard to action priorities and strategies to be included when the science and innovation policy and existing measures were updated. It was disbanded when work finished on the Québec Research and Innovation Strategy in 2006.

The Québec Research and Innovation Strategy propose three broad functional priorities: 1) strengthen public research, 2) enhance support for industrial research and innovation in the private sector, and 3) supplement and strengthen existing transfer and development mechanisms.

Like previous policy documents, this strategy reiterates the importance of priority-setting. It affirms that resources invested in public research must be "targeted in order to create critical masses that can excel and play a notable role in major research projects [...] and that are focused in areas of strategic importance to economic development and the needs of innovation.[70]" However, it does no more than list various technologies already considered strategic by MDEIE (biotechnologies, genomics, nanotechnologies, etc.), without explaining how it identified and assessed these priorities.

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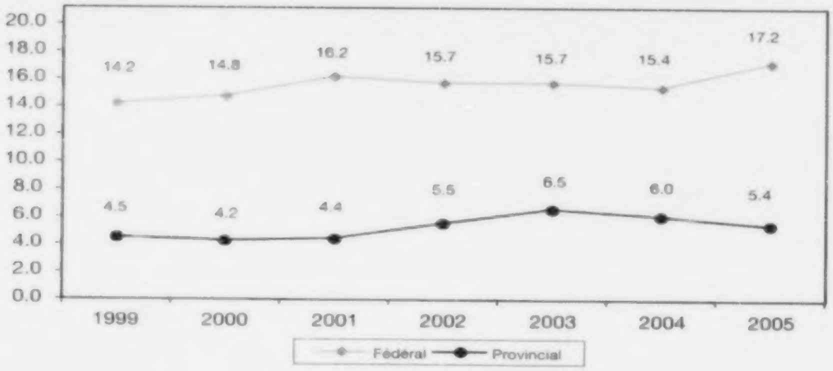
[70] Gouvernement du Québec (2006), *An Innovative, Prosperous Québec. Québec Research and Innovation Strategy*, Quebec City, Ministère du Développement économique, de l'Innovation et de l'Exportation (Ministry of Economic Development, Innovation, and Export Trade), p. 20, http://www.fqrsc.gouv.qc.ca/upload/documents/fichiers/document_21.pdf.

4.2 The Federal Context

4.2.1 The Federal Government's Substantial Contribution to Public Research Funding in Québec

The Québec government is not the sole source of public support for research and innovation. The federal government funds a large portion of the gross domestic expenditure on research and development (GERD) in Québec, as illustrated in the following graph.[71]

Figure 2 – GERD Funding Sources – 1999-2005 (Québec, percentage)



Source: Databank of Official Statistics on Québec (DBOS), Government of Québec, 2008.

The gap between the two levels of governments' funding of GERD is mirrored in domestic spending on Business Enterprise Research and Development (BERD) and Higher Education Research and Development (HERD).[72] Substantial federal support for research activities in Québec, particularly since the early nineties, has come with new eligibility conditions.

For example, for several years the Canada Foundation for Innovation (CFI) and the Canada Research Chairs Program have obliged universities to develop strategic research plans in order to obtain funding for their research activities and necessary facilities. The plans require that postsecondary educational institutions set "priorities in areas that integrate ideas and knowledge from many disciplines and sectors, and that build on their distinct advantages.[73]" For research chairs, the university must demonstrate the importance of the chair to the development of its own strategic research or, as the case may be, to that carried out in its affiliated establishments, institutes, or hospitals.

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[71] GERD is an indicator of domestic spending on research and development.

[72] See Appendix 6.

[73] Canada Foundation for Innovation (2008), *Policy and Program Guide*, Canada, Canada Foundation for Innovation, http://www.innovation.ca/docs/guide/2008/2008_cfi_guide_e.pdf.

By September 2008, 71 universities and colleges in Canada had submitted strategic research plans to obtain a Canada Research Chair.[74] Thus, more than 70% of member institutions of the Association of Universities and Colleges of Canada had carried out a priority-setting process as part of their overall planning.

In addition to these priority-setting initiatives by universities and colleges, spurred by the imposition of selection criteria for obtaining funding, there are targeted funding programs provided by various federal granting agencies:

- As discussed in Chapter 2, Natural Sciences and Engineering Research Council of Canada has its own procedure for establishing new targeted research areas and themes. This priority-setting process informs the Strategic Network Grants Program, which seeks to boost research and training in targeted areas to improve quality of life in Canada.
- Social Sciences and Humanities Research Council also awards strategic research grants to targeted research projects on social, economic, and cultural questions related to contemporary issues.
- Canadian Institutes of Health Research have carried out a number of initiatives in cross-cutting research in niche areas that represent exceptional development opportunities. These strategic research projects address health research priorities set by the Institutes as a group.[75]

4.2.2 The impact of the federal context on how research priorities are set in Québec

In Canada, priorities are set by stakeholders at various levels. Federal bodies develop research and innovation priorities to guide their investments in the Canadian provinces. This is in addition to:

- national priorities established by the Canadian government and set out in Canadian research and innovation strategies; and
- priorities set by each Canadian province, which underpin their research and innovation policies and are determined according to processes specific to each government.

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[74] For summaries of these strategic research plans, visit the Canada Research Chairs Program website: http://www.chairs.gc.ca/web/program/srp/srp_list_e.asp.

[75] Canadian Institutes of Health Research (2004), *Investing in Canada's Future: CIHR's Strategic Plan for Health Research and Innovation*, Canada, Canadian Institutes of Health Research, http://www.cihr-irsc.gc.ca/e/20266.html.

Priorities set by the Canadian government, traditionally of a functional nature, have in the past few years been aligned with national thematic research priorities. The most recent example of this goes back to June 2006 when the federal government requested that Council of Canadian Academies assess Canada's strengths and capacities in science and technology in order to identify the areas in which the country excels. The assessment aimed to 1) support the development of a science and technology strategy in Canada and 2) fuel reflection on the most appropriate methodological approach to adopt over the long-term for assessing Canada's scientific and technological strengths.[76] Council of Canadian Academies established a priority-setting process specifically designed to fulfill these objectives.

Sidebar 14 – Council of Canadian Academies Priority-setting Process (2006)

In 2006, Council of Canadian Academies designed a priority-setting exercise at the request of Minister of Industry to explore Canada's strengths in science and technology. The following four methods were used:

- **Large-scale opinion survey**

  Exclusively conducted online by the EKOS firm, this survey aimed to canvass the opinions of 1,529 science and technology experts in Canada. The Council recruited these experts using its own list of contacts in universities, government, the private sector, and member academies (20% of respondents were from Québec). Respondents were asked to choose general research areas they knew well and to evaluate them in light of Canada's strengths as well as current trends. They also were asked to assess science and technology facilities in terms of Canada's competitive advantage and to choose emerging technologies likely to enable Canada to position itself internationally.

- **Metrics**

  Science-Metrix performed an analysis of bibliometric data (research published in scientific journals) and technometric data (patents granted over a given time period) provided by Observatoire des sciences et des technologies du Québec (Québec Science and Technology Observatory).

- **View from abroad**

  A summary of reports and comments from scientific advisors and trade commissioners in Canadian embassies around the world was produced, with the focus on science and technology agreements between Canada and other countries.

- **Literature review**

  The Council reviewed relevant publications, including those on internationally comparable indicators of various aspects of national science and technology advantages. This step served to identify various foresight exercises targeting emerging technologies or research areas.

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[76] Committee on the State of Science & Technology in Canada (2006), *The State of Science & Technology in Canada. Appendix A*, Ottawa, Council of Canadian Academies, http://www.scienceadvice.ca/documents/Complete%20Report.pdf.

Sidebar 14 (suite)

At the end of this exercise, Council of Canadian Academies selected four broad areas where Canada is particularly strong:

- **Natural resources** (natural resource sciences and technological applications, especially mining and energy).
- **ICT** (sciences and technologies related to telecommunications, computers, robotics, and new media).
- **Health and associated life sciences** (cancer research, neurosciences, circulatory and respiratory health, infectious and immunological diseases, aging, genomics and proteomics, plant and animal biotechnologies).
- **Environmental sciences and technologies** (climatology, oceanography, hydrology, environmental engineering, hydrogen and fuel cell technologies, urban geography).

A number of subsectors and research areas are also mentioned in this report and were tagged as strengths in one or more of the four steps in the process – aerospace, transportation, optics/photonics, astronomy, and astrophysics.

Apart from the broad thematic priorities, this exercise highlighted other, more functional advantages, such as inter- and multidisciplinarity and a culture of collaboration and networking. It also revealed Canada's weakness with regard to the commercialization of research results and the transformation of technology into concrete applications.

In 2007, based on the results of Council of Canadian Academies priority-setting exercise, the Canadian government published its new science and technology strategy *Mobilizing Science and Technology to Canada's Advantage*. This strategy identifies a number of functional priorities, but also targets the four broad priority areas set forth in the Council of Canadian Academies' report:

- Environmental sciences and technologies
- Natural resources and energy
- Health sciences and life sciences technologies
- Information and communications technologies

Entrenching clearly stated thematic priorities in Canada's science and technology strategy changed how part of federal R&D funding was directed. Where once granting agencies, universities, and other stakeholders were solely responsible for identifying thematic priorities, all of a sudden there was a powerful new national player in the ring who affected the priority-setting processes of other stakeholders in Canada's innovation system.

Traditionally this engendered two overall concerns for Québec. It was important to avoid duplicating federal funding, but at the same time Québec needed to successfully compete with the other provinces in order to obtain its share. History demonstrates that Québec succeeded by using creative approaches. The weight of federal funding influenced the Québec government's public research funding strategy and therefore the priorities it set over the years. Thus the federal government's priority-setting initiatives perhaps reduced Québec's room to maneuver, but it also created opportunities.

Rather than competing with the federal government, Québec opted for a strategy of complementarity. It implemented programs to boost strategic research in key thematic areas. This approach also fostered collaboration between stakeholders, including concerted actions by Québec granting agencies and multidisciplinary research, with considerable support from Valorisation-Recherche Québec. The federal context, together with the initiatives of a number of Québec research and innovation bodies, has resulted in Québec's gradually crafting a creative, original approach.

These circumstances also spurred reflection on how to set Québec's research and innovation priorities while experimenting with various priority-setting methods and processes.

4.3 Strategic Action by Québec Stakeholders

In the past, certain economic or technology sectors have often undertaken to set priorities within their own fields of specialization. Génome Québec did this in 2007. Following consultation with various partners, it analyzed Québec's strengths and assets in genomics for its next strategic plan.[77] Nanotechnology[78] and ICT are other sectors that have done the same. In recent years, stakeholders in Québec's innovation system, rather than waiting for priorities to "emerge" on their own, have taken the situation in hand because they themselves have needed to set priorities for day-to-day purposes. This has allowed them to develop expertise in the field and reflect on the best priority-setting methods.

Thus, many have chosen to look to "key sectors" or "strategic niches" as a way to assure international clout or create a lever effect to draw investment to Québec from elsewhere in Canada and abroad. Ministère du Développement économique, de l'Innovation et de l'Exportation (Québec's Ministry of Economic Development, Innovation, and Export Trade) is an example of this trend, setting up the ACCORD program (Concerted Action for Regional Development Cooperation) in 2002.

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[77] Génome Québec (2007), *Pour un Québec plus compétitif en génomique. Consultations auprès des partenaires* (For a More Competitive Québec in Genomics. Consultations with Partners), Québec City, http://www.genomequebec.com/GQgenomequebec/publications/pourUnQuebecPlusCompetitifenGenomique.pdf.

[78] In 2003, MDEIE asked Samson Bélair Deloitte & Touche to take a look at nanotechnology in Québec. The firm painted a portrait of the sector in a document entitled *Portrait des activités de nanotechnologies au Québec* (Portrait of Nanotechnology in Québec) in which it identified promising research sectors to target as nanotechnology priorities. The document also analyzed the strengths, weaknesses, opportunities, and threats for the sector in Québec. It is available from http://www.mdeie.gouv.qc.ca/fileadmin/sites/internet/documents/publications/pdf/science_technologie/fr/publications/nano0302.pdf.

Sidebar 15 – MDEIE's Concerted Action for Regional Development Cooperation

The ACCORD program (Concerted Action for Regional Development Cooperation) was inspired by cluster strategies in countries like the United States and Finland, industrial districts in Italy, and competitiveness clusters in France.

It is an open-ended strategic approach to regional economic development designed to evolve over time. The project was first submitted and discussed before Comité des priorités (Québec's Committee on Priorities) and got off the ground with the submission of a brief[79] to Québec's cabinet in March 2002.

The ACCORD program primarily seeks to identify and develop niches of excellence in every region of Québec in order to set up regional productive systems throughout Québec that can hold their own not just in North America but all around the world. It has four main goals:

1. Position Québec's regions as the place for specific industrial skills recognized in North America and worldwide.
2. Boost productivity and employment through innovatión and export trade.
3. Identify concrete economic projects for Québec's regions that will spur growth.
4. Foster the development of industrial networks between and within regions.

Every project starts with a regional ACCORD committee being set up to decide which niches of excellence to develop.[80] Niches are identified by:

- drawing inspiration from the strategic plans of regional development councils and work carried out by various organizations and stakeholders in the field;
- referring to a criteria grid drawn up with Société générale de financement du Québec (Québec's General Investment Corporation), MDEIE, and a consultancy firm; and
- taking into account the long-term growth potential, the potential for job and wealth creation, the real competitive advantage, the need to act, and the impact on the development of the industrial system.

Once niches have been selected, participants must draw up a strategy (long-term vision) and action plan (projects, initiatives to take within five years) for every niche of excellence in each region. Indepth studies on domestic and international market trends and positioning provide complete data for developing a strategy to fit each niche. For each niche of excellence, the strategy and action plan are then made official in an implementation agreement between the Québec government and the region in question.

To date 15 regions have taken part in the ACCORD project and identified their niches of excellence. The government's objective is to sign 35 implementation agreements with regional economic partners by 2010, thereby ensuring the development of all niches of excellence identified by the regions.

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[79] Gouvernement du Québec (2002), *Un projet national: l'Action concertée de coopération régionale de développement (ACCORD)* (A National Project: Concerted Action for Regional Development Cooperation, part accessible to the public), Québec City, Government of Québec.

[80] "Niches of excellence" are groups of interrelated economic activities through which regions plan to position themselves competitively in relation to other regions and international markets.

This structured approach helps raise the profile of regional assets that could help Québec fend off the negative effects of globalization. Although it does not set out to determine research priorities, ACCORD nevertheless fosters collaboration between stakeholders and fuels discussion of Québec's economic strengths and assets.

Providing Québec with the ability to leave its mark and conduct strategic research on the international stage was one of the main goals of **Valorisation-Recherche Québec (VRQ)**. From 1999 to 2006 VRQ's mission was to help strengthen university research and increase its benefits for Québec society. Armed with $170 million in funding over seven years, VRQ's research component sought to develop Québec's strategic investment capacity by:

- training critical masses in collaborative, multidisciplinary research in thematic fields of research deemed to be priorities for Québec;
- using these investment funds as a lever to obtain external funding on other levels (federal and international); and
- forging ties between knowledge producers and users.

To this end a number of programs were created, including one entitled *Projets d'envergure de recherche* (Major Research Projects), which is aimed specifically at Québec's key sectors. The program required its own methodological process to identify key sectors, as outlined below.

Sidebar 16 – VRQ's Priority-Setting Process (1999-2006)[81]

A substantial part of VRQ funding was devoted to large-scale projects representing major opportunities for scientific research development for which funding could not be guaranteed in whole or in part through regular Québec government programs. To be considered opportunities, the projects had to improve and develop research facilities or spur research in promising niches.

The program therefore had to be targeted and needed to be capable of attracting both international researchers and new industries.

The VRQ board consequently set up an advisory committee made up of the chairs of granting agencies in Québec, the VRQ vice president of research, its CEO, and a top level consultant to choose the fields in which these large-scale projects were to be carried out.

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[81] Valorisation-Recherche Québec (2006), *Projets d'envergure de recherche - La démarche* (An Approach to Major Research Projects), http ://www.vrq.gouv.qc.ca/envergure.html.

Sidebar 16 ***(suite)***

In addition to the knowledge of advisory committee members, a number of information sources were also used, including:

- University projects in development for which funding was being sought.
- Data collected when the Québec government's science policy was drawn up.
- University strategic plans.
- Canada Foundation for Innovation (CFI) applications.
- Information from the Science and Technology Observatory.
- Various research policy documents from national and international organizations.

The following criteria were used to structure the process:

- Probability that research in the field would have a measurable impact on Québec's development (relevance).
- Capacity for research and excellence (excellence).
- Lack of usual funding sources (need for funding).
- Future prospects or likelihood of self-funding after VRQ (viability).

Fields chosen for funding were divided into three categories:

1. Emerging fields

New or emerging fields of research on the international scene in which Québec could play a leading role. The three selected fields were 1) nanotechnologies, 2) multimedia content, and 3) bioinformatics and biostatistics.

2. Value-added projects

Fields with major research resources and a vast potential for social and economic benefits. The selected fields were 1) aeronautics/aerospace, 2) online learning, 3) climate change, 4) microelectronics, and 5) school success.

3. Research service platforms

Projects seeking to put in place organizational structures or services to concentrate research data collection and knowledge transfer expertise. The selected fields were 1) an information platform on children's well-being, 2) infrastructure to promote clinical research in Québec, 3) a database on the targeted cohorts of children born at risk, 4) school success assistance, 5) Réseau intégré de recherche en santé (Québec Integrated Health Research Network), and 6) the BALSAC population register.

Many large Québec research consortiums have seen the light of day thanks to strategic funding from VRQ. Good examples are Genome Québec, Institut de recherche/création en arts et technologies médiatiques, HEXAGRAM (Institute for Research and Creativity in Media Arts and Technologies), NanoQuébec, Consortium sur la climatologie régionale et l'adaptation aux changements climatiques, OURANOS (Consortium on Regional Climatology and Adaptation to Climate Change), and Consortium de recherche et d'innovation en aérospatiale du Québec, CRIAQ (Québec Aerospace Research and Innovation Consortium).

VRQ was disbanded in 2006. It was not replaced, but part of the funds earmarked for strategic and partnership research were taken over by granting agencies and MDEIE. Yet VRQ had demonstrated Québec's talent and creativity in organizing collaborative support for strategic research of real international import. Currently no other organization has the capacity to rapidly forge partnerships and intervene on the cutting edge of three broad research areas (health, natural sciences and technology, and social sciences).

Many stakeholders remain involved in supporting strategic research, including the **three Québec granting agencies**. Traditionally, each agency has set its own priorities for supporting publicly funded strategic research programs. Their priority-setting processes, developed and carried out internally, are specific to each agency.

- Fonds québécois de la recherche sur la société et la culture–FQRSC (Québec Fund for Research on Society and Culture) has four strategic goals, one of which is to "Support Research on Québec's Key Social, Economic, and Cultural Priorities,[82]" based on a number of challenges identified by CST's STS Perspectives project.
- Fonds de la recherche en santé du Québec–FRSQ (Québec Fund for Health Research) identified three broad functional priorities in its 2007-2010 strategic plan, the second being to target priority areas. Thus FRSQ seeks to step up its support for strategic research in fields such as the neurosciences and mental health, aging and frailty, cancer, and societal illnesses (cardiovascular disease, diabetes, and obesity).
- Fonds québécois de la recherche sur la nature et les technologies–FQRNT (Québec Fund for Nature and Technology Research) has studied both thematic priorities and the priority-setting process. Of great educational value, these reflections on priority-setting, its importance in the current context, and its methodology, are presented in *Les priorités en recherche. Cadre de référence pour le plan triennal 2006-2007* (Research Priorities: Framework for the 2006-2007 Three-Year Plan) published in October 2005.[83] This document explores all the various types of priorities, from "functional" priorities to emerging scientific fields of great promise. FQRNT laid the methodological foundations for a unique approach by identifying four research sectors or themes that merit substantial public funding over the coming years.[84]

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[82] Fonds québécois de la recherche sur la société et la culture (2008), *Planification stratégique - orientation 2 : priorités stratégiques.* (Strategic Planning - Direction 2: Strategic Priorities), http://www.fqrsc.gouv.qc.ca/fr/fqrsc-en-bref/planification-strategique.php#orientation2.

[83] Fonds québécois de la recherche sur la nature et les technologies (2005), *Les priorités en recherche. Cadre de référence pour le plan triennal 2006-2009* (Research Priorities: Framework for the 2006-2007 Three-Year Plan), Québec City, http://www.fqrnt.gouv.qc.ca/documentsPublications/pdf/2005/prioritesRecherche.pdf.

[84] These sectors are nanotechnologies, climate change, hydrogen technologies, and cutting edge information and communications technologies (ICT).

Subsequent to this, FQRNT published its 2007-2010 strategic plan in May 2007 setting out its priorities and providing a more detailed explanation of its priority-setting approach and the logic underpinning its choice of priorities.

Sidebar 17 – Fonds québécois de la recherche sur la nature et les technologies (Québec Fund for Nature and Technology) Priority-setting Initiative

The 2007-2010 strategic plan of Fonds québécois de la recherche sur la nature et les technologies (FQRNT) is a continuation of the reflection initiated in the document *Les priorités en recherche*. It presents a mixed priority-setting process (sectoral and functional) centered around four broad categories of priorities:

1. Broad research area.
2. Sectors that reflect the unique character of Québec and its regions.
3. Emerging scientific and technological fields of great promise.
4. Highly competitive sectors in which Québec is, or could become, a world leader.

For each of these broad categories, FQRNT chose certain priority sectors and the most appropriate functional measures for developing them. FQRNT based its choices on the following four criteria:

- The importance of the issues the sector raises.
- The level of research expertise in Québec.
- The current level of FQRNT funding, notably through the Strategic Groups and Concerted Action programs. These two programs cover many research fields and are a good indicator of the range of research expertise in other FQRNT programs.
- Potential avenues for FQRNT.

Once its reflection completed, FQRNT presented its list of priorities, which are reflected in the research themes included in its strategic categories:

Figure 3 – Research Themes by Strategic Category 2006-2007

1. Broad Research Area

Mathematics
Astronomy
Neurolinguistics

2. Sectors That Reflect Québec's Unique Character

Ecosystems
Manufacturing and construction
Transportation
Natural Resources

3. Emerging Fields of Great Promise

Nanosciences and nanotechnologies
Cutting edge ICT
New health technologies
Genomics

4. Highly Competitive Sectors

Aeronautics and aerospace
Pharmaceuticals and biotecnologies
ICT

Québec universities, with their high concentration of researchers, are important knowledge producers and key players in training and attracting highly qualified workers. Like all other stakeholders in the innovation system, they have always had to set key priorities in order to ensure their development and establish their reputation locally and internationally. As discussed in the previous section, they also have to meet more and more exacting conditions to obtain their share of federal funding. This leads them to set thematic and functional priorities laid out in strategic plans that reflect their strengths and advantages in specific research fields.

A university's priority research areas primarily stem from the presence of researchers of international caliber, researchers renowned for their excellence and who advance global scientific knowledge. These priority research fields therefore represent a competitive advantage and thus enable universities to garner a larger share of the funding.

A number of universities, faced with complex internal priority-setting processes and often under pressure from their departments, have recently experimented with novel priority-setting processes that are more methodical, more rigorous, and especially more collective. The working groups set up by Commission de planification de l'Université du Québec (University of Québec Planning Commission), whose priority-setting process is outlined in the following box, have adopted a unique approach that builds on the ties between nine large Québec universities.

Sidebar 18 – Commission de planification de l'Université du Québec (University of Québec Planning Commission) Integrated Approach to Research

In 2004, members of Université of Québec Planning Commission decided to join their forces on shared priorities in working groups chaired by the university's rectors. This kicked off University of Québec's integrated approach to research, which aimed to 1) identify priority growth sectors 2) create a favorable climate for a holistic, collective vision of research subjects, and 3) set up projects that draw on related or complementary disciplines covering all fields of knowledge.

When launching a new theme, the Commission draws on the expertise of the vice rector of teaching and research at University of Québec to:

- analyze and document possibilities for developing these themes in the network;
- propose new themes based on their academic, social, economic, scientific, or political value; and
- make recommendations on opportunities for starting up a new theme.

Sidebar 18 ***(suite)***

The Commission then sets up a working group of four to six rectors chaired by one of them to promote and guide research activity on the theme. The vice rector of teaching and research organizes a meeting between the working group and research professors in the network to share training and research expectations and needs. The vice rector then proposes actions and activities to the working group and supports network members in carrying them out. Whenever the vice rector deems it appropriate, the Commission can set up a formal or informal external advisory committee made up of members of the political and business communities, to advise it on its work on the theme.

The themes are selected according to the following criteria:

- **Provincial** – The themes represent important issues in Québec, as reflected in the private sector, political and legislative programs, and the media.
- **Collective** – They involve all institutions in University of Québec network as well as a critical mass of research professors.
- **Synergistic** – Working on them collectively enables the achievement of more ambitious objectives, an exploration of new horizons, and therefore significant added value for their institutions' work.
- **Multidisciplinary** – Issues underpinning them are varied in nature and generate multidisciplinary projects that foster interdisciplinary sharing.

As of March 2009, two types of themes had been developed:

- **Sectoral themes**, which address multidimensional issues like water, health, energy, and design
- **Cross-cutting themes**, which deal with more specific issues that may arise in the sectoral themes, which is notably the case of distance learning and student mobility.

Because the sectoral theme "Regional Development" pursues transversal objectives, it cuts across the other sectoral themes.

The list of works and advisory reports published by **Conseil de la science et de la technologie** (Québec Science and Technology Council) points to the Council's interest in priority-setting dating back to its founding in 1983, and to even before. For example, CST organized a symposium entitled "Priorities for Québec Science Policy" in 1984 with a view to identifying priority issues in Québec in cooperation with the scientific community. Starting in the nineties, it also produced a series of advisory reports identifying key functional priorities, for example *Urgence technologie : pour un Québec audacieux, compétitif et prospère* (Emergency: Technology for a Bold, Competitive, and Prosperous Québec, 1993) and *Intensifier l'innovation : les orientations prioritaires* (Towards a Québec Innovation Policy: Strengthening Innovation: the Priorities, 1999).

In 2003, CST experimented with a new process, termed "bold and novel" by a number of international experts because it adopted a foresight approach that was based on social demand. In cooperation with various public and private partners[85] the STS Perspectives project polled Quebecers in order to identify the main socioeconomic challenges that Québec society will have to face in the course of the next 15 to 20 years. With the help of researchers and knowledge users, the project aimed to direct part of research and innovation work toward the selected social issues.

Sidebar 19 – Summary of the STS Perspectives Approach

Phase I

Defining the main socioeconomic challenges facing Québec society to which science and technology can contribute in a significant way (15 to 20 year time line)

↓

Step 1

Consultation of Quebecers on their concerns for the future (focus groups and questionnaire)

Step 2

Identification of 40 socioeconomic challenges in Québec by key figures from all walks of life (foresight workshops)

Step 3

Selection of seven challenges by researchers taking into account the expected contributions of science and technology (online consultation)

Step 4

Presentation of the selected challenges in the form of thematic reports (working groups)

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Phase II

Development of research strategies for each challenge (researcher/user working group)

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[85] For the complete list of the CST's partners in the STS Perspectives project, visit the website http://www.perspectives-sts.qc.ca/spip.php?page=partenaires&id_article=12.

The seven challenges in Phase I were to be developed and implemented by knowledge users and producers with a view to developing research strategies.[86] The following challenges, listed in Sidebar 20, were selected.

Sidebar 20 – Seven Challenges Arising from Phase I of the STS Perspectives Project

1. Promote the adoption of healthy lifestyles, based on a preventive, holistic vision of physical and psychological health and on efforts to make people responsible for their own health.
2. Increase the efficiency of the public healthcare system, which must support a gradually aging society while at the same time controlling costs.
3. Develop natural resources and manage waste more efficiently using a sustainable development approach to such an extent that Québec becomes a world leader in this area.
4. Provide top quality, universally accessible education that combines rigor, creativity, flexibility, and responsible citizenship accessible.
5. Target strategic and priority market niches in the areas of research, economic development, and education based on current strengths and emerging sectors.
6. Reduce dependency on fossil energy and make Québec a leader in the fields of energy efficiency and renewable energy, mass transit, and new environmental technologies.
7. Adopt innovative interventions for controlling poverty and the factors that generate and maintain it so as to stave off the consequences of poverty such as marginalization, a sense of powerlessness, inequity, and violence.

Praised by international foresight experts as an outstanding and original project, STS Perspectives is a collective, explicit exercise that can inspire other stakeholders in Québec to set their own research and innovation priorities.

In recent years, there has been a wealth of collaborative research projects that researchers and practitioners have designed and carried out together. However, it is much rarer to see researchers and practitioners negotiating at the same table to collectively develop entire research strategies that incorporate both scientific concerns and the perspectives of knowledge users. STS Perspectives demonstrated that it is possible to identify social demand for new knowledge and technologies, to have researchers commit to it, and to translate it into scientific priorities.

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[86] Completed strategies are available at http://www.cst.gouv.qc.ca/LE-PROJET-PERSPECTIVES-Science,384.

4.4 Observations

This all too brief overview of the development of Québec research and innovation policy, the federal context, and a number of recent priority-setting experiences carried out by Québec stakeholders points to the following observations:

1) Québec has set research and innovation priorities for at least three decades. Although primarily functional in nature, they have been complemented more recently by thematic or sectoral priorities.
2) The importance and necessity of setting priorities has been stressed many times in research and innovation policy and strategy documents.
3) A number of factors, including the predominance of federal public funding of R&D, have motivated Québec to position itself strategically using a creative and innovative approach to the way it funds and sets its priorities for R&D.
4) There is relatively broad consensus in Québec with regard to certain key sectors or cutting edge technologies (ICT, biotechnologies, nanotechnologies, aerospace, and pharmaceuticals, etc.).
5) Regardless of type of priority, the priority-setting process has not been clearly defined up till now.
6) There has been no tendency to date to determine priorities based on a medium or long-term perspective (foresight exercises have been rarely used).
7) In recent years there has been renewed interest, in Québec and Canada, in setting research and innovation priorities as well as in identifying attendant issues and objectives and improving the process.

So not only is priority-setting an essential part of an ongoing process of forging a world-class innovation system, but Québec is in a position to set its priorities in a unique way because it has certain singular qualities that allow it to develop an original, innovative approach. To do this it needs to improve its priority-setting process by making it more systematic and being more creative in adapting the process to the existing environment, practices, and know-how. Without going into great detail, Chapter 5 presents recommendations on how to achieve such an approach.

Chapter 5
Developing a Priority-Setting Process Adapted to Québec's Needs

Priority-setting is not new in Québec. Over the past three decades, all Québec science policies have set various functional and thematic priorities that have progressively contributed to the development of a national innovation system.

To face the modern-day challenges of globalization, however, we need to reexamine how we do things. Québec already invests extensively in research and innovation, and its innovation system has a strong track record. However, to maximize the benefits of these investments in a context of growing international competition, Québec needs to adopt a more systematic and rigorous approach to identifying priorities. Updating the Québec Research and Innovation Strategy (QRIS) provides an opportunity to do just that.

5.1 Gains for the Québec Research and Innovation Strategy

Identifying priorities for research and innovation is a collective exercise that helps people develop tools to better manage uncertainty and improve their understanding of a society's challenges, capabilities, and strengths.

Over the years, various countries have understood the importance of making choices, but especially of making them strategically by means of a process that:

- Requires greater clarity and transparency.
- Is more systematic and reflective.
- Emphasizes collaboration and stakeholder involvement.
- Allows for diversification of research and innovation priorities.

Societies that have recently enhanced their priority-setting processes have reaped the following benefits:

- *Priority-setting allows a society to collectively assess its strengths and weaknesses*

  Assessing strengths and weaknesses is a way to sketch a portrait of the current situation. It draws on identification and analysis and requires extensive data availability as well as the effective gathering and rigorous processing of information. It always involves group reflection – whether in an open or closed working group setting – using methodology selected on the basis of the objectives that have been set. Experience at the international level shows that assessing innovation system strengths and weaknesses is a crucial step in priority-setting because it provides stakeholders with a general understanding of the context in which priority issues arise.

- *Priority-setting enhances a society's influence and position in a globalizing world.*

  Once identified, thematic priorities become driving forces that allow societies to showcase their areas of excellence on the world stage. This positioning is key to boosting collaboration with other countries and regions around the globe. By putting their strengths and priorities out front for all to see, societies can increase their likelihood of participating in majo international research initiatives while, at the same time, helping stakeholders integrate and master knowledge produced elsewhere.

- *Priority-setting makes it possible to respond to the major social challenges facing the population*

  Many contemporary socioeconomic issues are global in scope. Addressing them requires joint research efforts that redefine traditional disciplinary boundaries. More and more local issues also require solutions incorporating science and technology. As a result, knowledge of these issues and the challenges they raise is increasingly important and has led a number of countries to take action and set priorities. The attention paid to social demand for new knowledge is also motivated by public pressure to ensure that R&D investments are socially and economically profitable. Not only are research priorities gradually becoming essential for fostering excellence and generating collective wealth, they are increasingly expected to contribute to a society's growth and well-being.

- *Priority-setting mobilizes numerous stakeholders and fosters collaboration.*

  Priority-setting exercises involve numerous stakeholders from multiple horizons, including the business community, development and transfer organizations, the research community, and government. Mobilizing these various actors helps ensure that a wide range of interests are taken into account when selecting research and innovation priorities. These exercises also engender collaborative networks, by the same token facilitating the appropriation and implementation of the chosen priorities. These important, highly sought-after benefits are often what encourage other societies to undertake this kind of exercise.

A more systematic approach to priority-setting also contributes to increase strategic intelligence[87] and helps maintain competitiveness in a globalizing world.[88]

The development of a systematic and recurring approach to priority-setting requires action at two levels:

1) Gradual development of world-class expertise that provides Québec with the capacity to analyze and monitor its national innovation system (strategic watch, foresight, statistical analysis, public policy analysis, bibliometric and scientometric analysis, etc).
2) Implementation of less isolated strategic actions that are underpinned by the creation of permanent networks facilitating the sharing and exchange of information and benefiting from the long-term financial support needed to achieve the anticipated results.

Historically, Québec has always been well positioned with respect to research and innovation at the international and federal levels. It has proven both effective and creative, adopting often-original strategies showcasing its excellence in Canada and elsewhere. To help Québec overcome the current economic crisis and any future crises, continue developing a strong and effective innovation system, and strategically position itself internationally, the government needs to rethink how it sets research and innovation priorities.

In addition to setting functional and thematic priorities, priority-setting in Québec should aim to:

- Bring stakeholders together to jointly define priorities for research and innovation.
- Provide Québec with strategic intelligence that is shared among concerned stakeholders.

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[87] Strategic intelligence is a process that allows an organization to process, structure, and interpret the data, knowledge, and information it possesses in a way that yields a greater understanding of the overall environment in which it operates. This type of analysis helps the organization better manage the risks associated with change by giving it a better grasp of situations likely to pose a threat to its integrity and growth, and thus helps reduce uncertainty in decision-making.

[88] Strategic intelligence has come under criticism in Québec in recent years. Pierrette Bergeron, among others, addressed the issue in a book published in 2000:
"This study has [...] shown that governments have policies, programs, and initiatives for disseminating and providing access to scientific, technological, economic, and social information. However, their approach to developing information and knowledge policy is disjointed and lacks a coherent vision, thus preventing the development of genuine strategic information engineering from a social intelligence perspective. Governments need to develop a comprehensive, integrated approach to government information and knowledge management. However, integrated does not mean centralized, but rather well coordinated and strategic." [Our translation]
P. Bergeron (2000), *Veille stratégique et PME. Comparaison des politiques gouvernementales de soutien* (Business Intelligence for SMEs: A Comparison of Government Support Policies), Québec, Presses de l'Université du Québec, p. 339.

- Pursue the development of world-class strategic research resources so as to be able to take advantage of opportunities here in Canada and abroad.
- Formulate an original and creative approach that enables Québec to identify and implement its own priorities.
- Allow public bodies to support research and innovation in accordance with key, jointly defined strategic priorities.

5.2 Recommendations

The time is ripe for Québec to change its strategy by adopting an original priority-setting approach that is in continuity with actions taken to date and builds on the synergy among stakeholders. To this end, Conseil de la science et de la technologie (CST) has drafted three recommendations that will be detailed in the following pages.

Table 16 — CST's Recommendations

Recommendation 1	That ministère du Développement économique, de l'Innovation et de l'Exportation adopt a more systematic, rigorous, and transparent priority-setting process to help draft future Québec research and innovation policies and strategies. To this effect, a number of key aspects should be taken into account: • Implementation of the priority-setting process for research and innovation should be inspired by factors that contributed to the success of major priority-setting exercises undertaken elsewhere in the world. • The priority-setting strategy should be designed to take into account Québec's specific characteristics. • The priority-setting strategy should be based on principles of governance in order to maximize participation and involvement in the exercise. • All exercises in priority-setting for research and innovation should be part of an effective strategic watch system that meets the highest international standards. • Responsibility for conducting exercises to identify research and innovation priorities should be entrusted to a group or body capable of securing broad stakeholder involvement and support.
Recommandation 2	That ministère du Développement économique, de l'Innovation et de l'Exportation, in conjunction with its partners, develop a portfolio of functional and thematic priorities that are adapted and flexible in order to meet the immediate and future needs of Québec's national innovation system stakeholders and the population.
Recommandation 3	That ministère du Développement économique, de l'Innovation et de l'Exportation continue to maintain a solid and comprehensive research base and provide support for the various phases of the innovation process.

Recommendation 1

That ministère du Développement économique, de l'Innovation et de l'Exportation adopt a more systematic, rigorous, and transparent priority-setting process to help draft future Québec research and innovation policies and strategies.

By definition, systematizing the process consists of adopting a set of practices aimed at reaching a final outcome. Systematizing priority-setting practices for research and innovation in Québec entails the following requirements:

- Developing a set of practices and methods specifically designed to identify priorities for research and innovation.
- Designing a recurrent approach that can be used at relatively regular intervals or on an as-needed basis to produce new policies and strategies or a new research and innovation action plan.
- Improving coordination of priority-setting initiatives by involving a strategic core of concerned stakeholders dedicated to this task.

Adopting a more systematic approach to priority-setting will not only allow us to further clarify the steps involved in identifying priorities for research and innovation, but to do so in a more coordinated and strategic way. To fulfill these three conditions, it is important to take into account specific requirements inspired by international and Québec experiences. These requirements are as follows:

- **Implementation of the priority-setting process for research and innovation should be inspired by factors that contributed to the success of major priority-setting exercises undertaken elsewhere in the world.**

Although priority-setting models from other countries and regions of the world can rarely be imported as is, foreign experiences do provide inspiration that can benefit Québec. This was one of the main conclusions of the Seminar on Priority-setting in Science and Technology held in June 2008 in Montréal.[89] Foreign experience accumulated over many years of reflection and practice in priority-setting has also helped set certain standards in the field, notably with respect to rigor and transparency, methodology, and the importance of stakeholder representativeness.

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[89] See Appendix 5.

Priority-setting initiatives for research and innovation must meet at least some of these standards to be recognized by peers and acknowledged by the international community. For this reason, it is important to take into account the conditions for successful priority-setting laid out in Chapter 3 of this advisory report.

- Collectively recognize the need to set priorities, a step requiring the broadest possible consensus among major stakeholders (institutions of higher learning, businesses, the research community, liaison and transfer organizations).
- Secure clear and consistent government support throughout the exercise.
- Stress the rigor and transparency of the process, taking care to further clarify the overall approach.
- Develop an effective communication strategy for the duration of the exercise to keep stakeholders and the public informed. Good communication improves the odds of stakeholder buy-in and allows for clear and precise messaging.
- Adopt a comparative perspective that highlights Québec's strengths and assets in a global context.
- Put in place a realistic management framework, backed by sufficient financial and human resources to see the project through.

At very least, a Québec approach to priority-setting must meet these six conditions if government authorities want it to be successful.

- **The priority-setting strategy should be designed to take into account Québec's specific characteristics.**

The effectiveness of the priority-setting process depends on its ability to draw on a society's contextual and cultural differences. Taking Québec's specific characteristics into account when developing a priority-setting approach can impact the nature of the priorities identified, the methodology used, the participants chosen for the exercise, and the strategies builded to implement the priorities that were selected.

The elements most likely to influence the choice of a priority-setting process for research and innovation in Québec are as follows:

- *A national innovation system that brings together a variety of stakeholders*

  Québec's national innovation system is composed of stakeholders who play multiple and varied roles and who interact and work together to foster innovation throughout the system (immediate and broader environment, and even internationally). Québec boasts a highly developed university network, numerous businesses that invest in R&D, agencies that provide innovation assistance and support, three funds exclusively devoted to public research funding, organizations dedicated to developing scientific and technical knowledge, and numerous development and transfer organizations.

All of these stakeholders have their own research and innovation priorities. Their contribution to decision-making on major priorities at the Québec level is therefore crucial. These stakeholders must be taken into account when developing a Québec priority-setting approach capable of garnering their support for shared goals. The diversity of interests adds to the complexity of the decision-making process, making dialogue even more critical. To this end, Québec society has developed numerous mechanisms to facilitate negotiations and cooperation between stakeholders (the public, business, experts, government authorities, the scientific community, etc.).

Throughout the world, policy centers are showing more signs of openness to broader stakeholder participation. Not only does Québec reflect this trend, it also has considerable advantages in this regard. Getting stakeholders on board to help set priorities for research and innovation is a new and crucial imperative, and this trend is consistent with Québec traditions.

- *The significant federal government contribution to public funding for research in Québec*

  Significant federal funding for research in Québec is another distinctive feature that must be taken into account in setting Québec priorities. The issue is broader and concerns all Canadian and Québec research and innovation policies, which would benefit from closer cooperation between the two levels of government. Priority-setting calls for some degree of acknowledgement of each other's priorities and, to the extent possible, mutual support in areas of overlap.

  Traditionally, this situation has led Québec stakeholders to adopt strategies that were complementary in nature. Rather than competing with federal programs, Québec sought to identify its own direction for research and innovation, supplementing federal government initiatives and ensuring it would obtain the maximum benefit. This approach – reflected in Québec granting agency procedures, tax credits, and the financing operations of Canada Foundation for Innovation – is just as relevant for priority-setting today.

  However, Québec must do more than simply adapt to federal priorities. Its priority-setting approach must be able to meet its own needs and be based in the realities it deems most important. And if for the sake of realism this is not possible without considering the impact of federal programs and funding on the Québec system, we can expect in return that federal priorities will take into account those set in Québec, as in other provinces. In this area of endeavor as in many others, the pursuit of efficiency and consistency should prevail.

- *A tendency to form strategic groups focused on major research themes*

  Research funding in Québec is also characterized by a tendency to form large strategic and multidisciplinary groups that bring together researchers of various origins around key themes. Certain original initiatives have helped foster this trend, including:

  - Funding programs by Valorisation-Recherche Québec, including coordinated actions, major research projects, and support for structural initiatives.
  - Strategic research programs introduced in recent years by federal and Québec grant agencies.

  These developments show a trend to focusing on research themes and promoting multidisciplinary collaboration. The thematic priorities identified in priority-setting exercises benefit from proven implementation methods and can take inspiration from priority-setting processes already employed by stakeholders open to the idea.

  Other historical, cultural, and socioeconomic characteristics may influence how Québec sets priorities (e.g., population size, language, the type of economy), which is why it is important to understand the general priority-setting context.

- **The priority-setting strategy should be based on principles of governance in order to maximize participation and stimulate involvement in the exercise.**

  The decision to undertake a priority-setting exercise is primarily motivated by the impact it may have on the innovation system and its member stakeholders. Evaluations of recent priority-setting exercises have shown just how effective the process is as a tool for education and for getting people involved. Priority-setting exercises are vital opportunities to reflect on the collective future of society, which is why it is important for them to emphasize dialogue and foster and facilitate networking.

  This challenge is central to priority-setting. Getting stakeholders involved is all the more crucial given that the innovation system is increasingly open and increasingly dependent on its underlying networks.

Sidebar 21 – Principles of Governance as Enumerated in CST's 2006 Brief

- Adopt and maintain a systemic vision of innovation.
- Ensure a clear, ongoing, and consistent government commitment to innovation.
- Involve innovation stakeholders in developing the strategy.
- Build on effective monitoring and continuous assessment of the innovation system.
- Bank on stakeholder abilities and interactions.
- Get society contributing to the innovation effort and its benefits.

As Québec participants and international experts stressed at the seminar on priority-setting in June 2008, Québec's choice of research and innovation priorities should ideally reflect the broadest possible consensus among stakeholders and an overall vision that takes everyone's interests into account. To this end, it is important to build on the six principles of governance listed in Sidebar 21. For example:

- Involve stakeholders from the research community (universities, colleges, research centers), business, and government (provincial, but also federal and municipal) - both knowledge producers and knowledge users - in the priority-setting process.
- Opt for methods that provide an understanding of both the supply of and demand for new knowledge, but that especially foster stakeholders interaction.
- Develop mechanisms that can also be used to identify the needs of the population, and even get the public involved in choosing Québec's priorities for research and innovation.

- **All exercises in priority-setting for research and innovation should be part of an effective strategic watch system that meets the highest international standards.**

Since the 1990s, OECD recognized the importance of strategic watches and foresight in priority-setting and, by the same token, in developing research and innovation policy.[90] Initiatives by numerous countries in this area testify to the growing importance that the gathering, processing, analysis, and selective dissemination of strategic information will have in decision-making.

Priority-setting exercises require the most complete understanding possible of issues and problems in research and innovation at the local, national, and international levels. For this purpose, strategic information plays a major role in every step of the process.

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[90] OCDE (1991), op. cit. p. 75-87.

To support the overall priority-setting process, current Québec practices need to be improved on four levels.

1. ***Strengthen the analysis, mapping, and monitoring of Québec's strengths and assets.*** Certain Québec stakeholders[91] already contribute to these analytical efforts to enrich our knowledge by way of their experience in this field. But priority-setting exercises demand that we do more, while at the same time encouraging work pooling and collaboration. It is also important to step up monitoring and collection of statistical data on research and innovation. Improvement in this area means providing sufficient funding to agencies that produce this data. It also means following the lead of other jurisdictions internationally and working to develop new indicators that can more effectively measure R&D impacts.
2. ***Encourage more research and analysis of public policy on research and innovation***. Since priority-setting is intrinsically linked to the development of public policy on research and innovation, it would be most advisable to develop additional tools for identifying and analyzing policy in this area. Countries[92] with agencies that do so have considerably increased their strategic intelligence capacities and now set the example for generating and disseminating knowledge in this area.
3. ***Extend evaluation to cover processes and not just results.*** International experience has made evaluation an increasingly important component of policy and strategy development in the area of research and innovation. The success of a Québec approach to priority-setting will depend in part on our ability to critically assess the overall experience. To the extent that we wish to systematize the priority-setting process, we need to make project evaluation a key step in improving our practices. And to do so, Québec must upgrade its evaluation practices and acquire the tools and expertise required to meet these new challenges.
4. **Sell decision makers on the importance of strategic intelligence**. Recognition of the importance of the strategic watch, foresight, and priority-setting processes starts with demystifying their meaning, their scope, and the skills they require. Education and awareness training is vital for developing Québec's strategic intelligence.

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[91] Examples include Observatoire des sciences et des technologies (Science and Technology Observatory) at Université du Québec à Montréal, Institut de la statistique du Québec, Statistics Canada, Centre interuniversitaire de recherche en science et technologie - CIRST (Inter-University Science and Technology Research Center) at Université du Québec à Montréal, as well as certain companies like Science-Metrix.

[92] The United Kingdom (PREST, SPRU), the European Union (Joint Research Center, TrendChart, Erawatch), and the United States (RAND Corporation, Centre for Science and Technology Policy Research, etc.) are good examples.

- **Responsibility for conducting exercises to identify research and innovation priorities should be entrusted to a group or body capable of securing broad stakeholder involvement and support.**

The decision to undertake a priority-setting exercise in research and innovation with a view to developing public policy lies with government authorities. The credibility of the exercise derives from a clearly expressed government commitment. Once that commitment is expressed, the exercise needs to be legitimized. International experience has shown that legitimacy depends a great deal on who is chosen to head up the exercise.

The degree of legitimacy the designated agency enjoys can substantially affect the impact and influence of the priority-setting exercise and amount of support for the selected priorities and their implementation. This is why it is important to choose a lead agency carefully. In light of the observations and lessons learned from foreign experiences, the ideal qualities to look for in an agency or other body tasked with leading a priority-setting exercise are as follows:

- Be able to provide support by having sufficient human resources (quantity, expertise, and quality) and financial resources available to carry out all aspects of the exercise.
- Have experience with large projects and a track record of effective management of similar assignments.
- Possess coordination skills and a capacity to rally a wide variety of stakeholders with different interests around a set of common goals.

Since priority-setting exercises are an opportunity to reflect on our joint future, the diversity of voices must be reflected in the very composition of the body leading the process.

Diversification of Research and Innovation Priorities

Systematizing the priority-setting processes allows us to develop an approach that is both stimulating and thorough, and meets the highest international standards. However, experiences in other countries show that in order to achieve excellence, the ability to create a context conducive to developing and implementing priorities is also vital. To do so, it is important to remember that no priority is independent of the context in which it was established.

The context in question is that of a vast, multifaceted research system (industrial research, research base, development and transfer, advanced worker training, etc.). It is also characterized by several strong economic sectors in which Québec has invested heavily in the past, and that have helped it make a name for itself internationally.

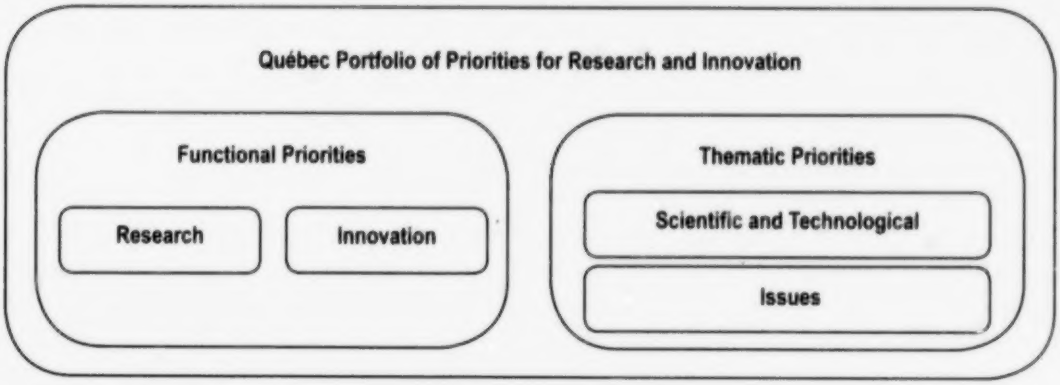
The type of priorities selected must reflect this diversity and allow for initiatives throughout the entire innovation system. For this reason, in addition to further systematizing the Québec priority-setting process, CST recommends:

Recommendation 2

That ministère du Développement économique, de l'Innovation et de l'Exportation, in conjunction with its partners, develop a portfolio of functional and thematic priorities that are adapted and flexible in order to meet the immediate and future needs of Québec's national innovation system stakeholders and the population.

The preceding chapters of this advisory report have shown that diversifying priorities enhances the effectiveness of action throughout the innovation system. To this end, priority-setting strategies must allow for the establishment of priorities that are limited in number, but of different types, both functional and thematic. Since each type of priority is a response to specific imperatives, this diversity must also be reflected in the very concept of thematic priorities. For example, this can be achieved by opting for issue-related priorities that also incorporate a technological or scientific component. The same goes for functional priorities, which must simultaneously allow for action within the two main components of the national innovation system–the research component (tax credits, funding of public research, universities, etc) and the innovation component (development and transfer, support for businesses, commercialization, etc.).

Figure 4 – Structure Diagram of a Québec Portfolio of Priorities for Research and Innovation


Québec Portfolio of Priorities for Research and Innovation
Functional Priorities
Research
Innovation
Thematic Priorities
Scientific and Technological
Issues

This portfolio makes it possible to act on several dimensions simultaneously while at the same time meeting a variety of needs linked either to the development of research, to technology, or to socioeconomic issues.

Diversity must be manifested in the nature of the priorities selected rather than in their number. Diversification does not necessarily imply multiplying the number of priorities, but rather making strategic choices that reflect Québec's existing strengths while at the same time acknowledging the importance of pursuing the development of a solid base for research and training.

The necessity of diversifying requires input from a wide cross-section of stakeholders to ensure that actions are suitable for all sectors. This is why the portfolio of research and innovation priorities for Québec should be defined in conjunction with a variety of partners, including granting agencies, universities, development and transfer organizations, sectoral ministries with research interests (in health, agriculture, education, environment, social solidarity, natural resources, etc.), and representatives of the business community. This is an opportunity for MDEIE to reiterate its role in leading and coordinating government initiatives in research and innovation.

Ongoing Development of Scientific Knowledge

Identifying functional and thematic priorities using a systematic, recurrent process entails constant renewal of priority themes. Renewal is only possible if society is able to produce new knowledge and incorporate and master the knowledge produced elsewhere.

For this reason, Conseil de la science et de la technologie recommends:

Recommendation 3
That ministère du Développement économique, de l'Innovation et de l'Exportation continue to maintain a solid and comprehensive research base and provide support for the various phases of the innovation process.

Québec's contribution to global knowledge production is modest. Its size and financial resources require it to make choices and focus on its strengths in order to differentiate itself from other societies. To be fully effective, however, priority-setting strategies must be designed for the long-term and must allow a society to understand and adopt knowledge and know-how produced elsewhere. Since Québec barely produces 1.1% of the world's knowledge, it is critical that it rise to the challenge of mastering scientific knowledge produced in other countries. For this reason, it is not only important to focus on certain key sectors, but also to:

- Maintain a high level of basic scientific knowledge acquisition in Québec universities and research centers.
- Have access to a sufficient pool of researchers in all possible fields, both in science and engineering and in the social sciences and humanities.
- Train a highly qualified workforce to serve as the driving force for innovation in the future.

Maintaining a solid and comprehensive research base also ensures the development of new fields of knowledge and of new technologies with the potential to become important assets for Québec in the coming years. The explosive growth in convergent technologies like biotechnology and nanotechnology and in other emerging fields could not have taken place without major advances in chemistry, physics, computer science, and mathematics.

Mastering scientific knowledge is critical, but it is not enough to ensure a society's survival in the context of globalization. Societies must also be able to transform knowledge into innovations that can produce wealth and ensure the population's well-being. For this reason, priority-setting exercises must take into account all the inherent dimensions of the innovation system and not only help define priorities for research, but also functional and thematic priorities for innovation.

Knowledge building, consistent support for the various phases of the innovation process, and skilled workforce training are core fundamentals that allow societies whose main priorities have been identified to adapt and react to unanticipated changes or more challenging economic circumstances.

Québec is already recognized for the quality of its innovation and research system. Maintaining excellence must remain the leitmotif for government initiatives in research and innovation.

Conclusion

In a world of accelerating globalization with research and innovation developing apace, the only way for societies to maintain their competitive edge and quality of life is to have a real sense of what their priorities are. As a result, many countries have revisited their priority-setting processes to make them more efficient, more productive, and above all more open and collective.

Québec is one of the societies faced with such challenges. Confronted with the need to set priorities, Québec has come up with original and creative ways in the past to contribute to the development of science and innovation. Now it must adapt once again by developing a new, more systematic, and more rigorous priority-setting approach to cope with today's challenges. Such an approach will have to be recurrent, forward looking, and based on Québec's unique situation, all while taking the federal context into account. It is also vital that the priority-setting process be conducted in concert with all stakeholders so that the ultimate choices converge toward common objectives.

This new approach will not only help guide research and innovation choices, but also provide the tools to develop greater strategic intelligence for concerned stakeholders to share. This is how societies best cope with uncertainty.

Research and innovation priorities must also enjoy broad and ongoing support for results to be achieved. Translating priorities into actual measures that meet with success will therefore require that governments pay appropriate heed to developing their innovation systems along with related research and the resulting technologies. Only through such recognition can the selected priorities make a meaningful contribution to society and its well-being.

Appendix 1
List of Priority-setting Exercises Used in this Advisory Report[93]

Country/Region[94]	Exercise	Date
Australia	Matching Science and Technology to Future Needs	1994-1996
Australia	**National Research Priorities**	**2000-2002**
Austria	**Austrian Foresight Program - Delphi Austria**	**1996-1998**
Austria (Vienna)	Research, Technology, and Innovation Policy in Vienna	2006-2007
Belgium	Socioforesight - Étude prospective en appui à la politique scientifique fédérale (Socioforesight - a prospective study in support of the federal science policy)	2001-2002
Belgium (Flanders)	Flanders 2015	2005-2006
Belgium (Wallonia)	**Promothée 1 - 40 technologies clés (Promethée 1 - 40 critical technologies)**	**1998-2000**
Belgium (Wallonia)	Les actions prioritaires pour l'avenir Wallon (Priority Action for the Future of Wallonia)	2005
Canada	The State of Science and Technology in Canada	2006
Canada	Looking Forward: S&T for the 21st Century	2005
Canada (Alberta)	**Alberta Science and Research Authority R&D Priority-setting Consultation: Guidance Toward an R&D Strategy for Alberta**	**1996**
Canada (Québec)	**Perspectives STS (STS Perspectives - Science, Technology, and Society)**	**2003-**
Canada (Québec)	**Projet ACCORD - Action concertée de coopération régionale de développement (ACCORD Project - Concerted Action for Regional Development Cooperation)**	**2002-**
Canada (Québec)	**Plan stratégique 2007-2010 du FQRNT : démarche de priorisation (FQRNT 2007-2010 Strategic Plan: Priority-Setting Process)**	**2007**

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[93] **Highlighted** priority-setting exercises were described in detail in the writing of this report. The analysis grids can be consulted online at http://www.cst.gouv.qc.ca/-fr-.

[94] These priority-setting exercises can be carried out at a national level (for governments), but also at an organizational level (for individual organizations).

(suite)

Country/Region	Exercise	Date
Canada (Québec)	**Les chantiers de la Commission de planification de l'Université du Québec (Workings of the University of Québec Planning Commission)**	**2004-**
China	National Critical Technologies	1995
China	Technology Foresight 2003	2002-2003
China	**Technology Foresight Toward 2020 in China**	**2003**
Czech Republic	**Technology Foresight 2002**	**2001-2002**
Czech Republic	Third Czech National Research Program 2009-2014	2006-2007
Denmark	Priorities of the National Strategy	1995-1996
Denmark	Danish Technology Foresight Program	2001-2004
Denmark	**Innovation Accelerating Research Platforms**	**2005**
Denmark	Research 2015: A Basis for Prioritization of Strategic Research	2007-2008
Denmark	Strategy Plan 2003-2007	2001-2001
Denmark	Visionary Areas	2005
Denmark	Energy Strategy 2025	2005
European Union	FISTERA - Thematic Network on Foresight on Information Society Technologies in the European Research Area	2003-2004
European Union	Emerging Science and Technology Priorities in the Triadic Regions (Europe, Japan, US)	Unavailable
European Union	**Emerging Thematic Priorities for European Research**	**2000-2001**
European Union	Critical Technologies for Europe	2004-2005
European Union (for the Seventh Framework Program 2007-2013)	European Technology Platforms	Unavailable
Finland	On the Way to Technology Vision	1996-1998
Finland	**FinnSight 2015**	**2006**
Finland	Tekes Strategy Focus Areas	2005
Finland	VTT's Roadmaps to the Future	Ongoing
France	Technologies clés 2000 (Key Technologies 2000)	1994-1995

(suite)

Country/Region	Exercise	Date
France	Technologies clés 2005 (Key Technologies 2005)	1999-2000
France	**Technologies clés 2010 (Key Technologies 2010)**	**2004-2005**
Germany	Technology at the Beginning of the 21st Century	1992
Germany	Delphi '98	Early 1990s
Germany	**Futur – The German Research Dialogue**	**2001–2005**
Greece	National Foresight Program	2001–2004
Hungary	**Hungarian Technology Foresight Program**	**1998–2003**
India	Technology Vision 2020	1995–1996
Ireland	**Technology Foresight**	**1998–1999**
Ireland	Strategic Technology Platform	2004
Italy	National Priorities for Industrial Research	1996
Japan	**Science and Technology Foresight Survey**	**2003–2004**
Luxembourg	Luxembourg First National Technology Foresight	2006–2007
Netherlands	Technology Radar	1998
Netherlands	The OCV Knowledge Themes	1992–1996
Netherlands	Themes Plus Talents	2001
New Zealand	The Foresight Project	1997–2000
Norway	Priority Areas	2004–2005
Poland	National Foresight Program Poland 2020	2006–2008
Portugal	Technology Foresight for Portugal 2000–2020	1999–2000
Russia	Russian Critical Technologies 2015	2004–2005
Russia	Long-Term Innovation Priorities for Bashkortostan	2005–2006
Slovenia	Technology Foresight Slovenia 2020	2004–2005
South Africa	National Research and Technology Foresight	1998
South Korea	Delphi Survey	1992–1994
South Korea	Vision 2025	1999
South Korea	Korea 2030	2003–2004

(suite)

Country/Region	Exercise	Date
South Korea	21 Future Technology Areas	Unavailable
Spain	**Priorities of the Fourth National Plan**	**2000–2003**
Sweden	Technology Foresight Project	1998–2000
Turkey	Turkish Science and Technology Vision 2023	2003–2004
Ukraine	Ukrainian STI 2025	2004–2006
United Kingdom	**Foresight Programme**	**1993–**
United Kingdom	Key Emerging Areas	2005–2006
United Kingdom	Thematic Priorities	1995, 2000
United States	**National Critical Technologies**	**1995**
United States	Memorandum on Research and Development Priorities	Annual presentation
United States	Global Technology Revolution 2020	2004–2005

Appendix 2
An Overview of Priority-setting Abroad

Europe

Europe has a complex situation all its own due to a political makeup of national and supranational decision-making bodies. The founding of the European Union has made it necessary to bring national priorities into line with those of the **European Commission** (EC), which participates financially in a number of leading research programs.

The EC's Seventh Framework Program focuses on nine key themes. Although a top-down approach was used to set these priorities, the EC is advised by a number of bodies on possible avenues for science and technology development, including the Institute for Prospective Technological Studies (IPTS) and the European Research Council.

In light of its new framework program, the EC has also set up 30-odd technology platforms to date. These platforms seek to outline strategy in areas where Europe's growth, competitiveness, and sustainable development depend on significant technological progress. They bring together stakeholders, spearheaded by industry, to set medium and long-term goals and science and technology development stages in order to substantially improve the everyday lives of citizens in a host of wide-ranging domains. Technology platforms are also an attempt to bring the priorities of European research into line with industry requirements.

A number of European countries are behind ambitious priority-setting exercises and have become something of a benchmark. Exercises respect each country's history and politics.

France is known for many of the priority-setting exercises it has undertaken since the 1960s. These include the "Key Technology" exercises conducted by Ministère de l'Économie, des Finances et de l'Industrie (Ministry of the Economy, Finance, and Industry) as well as a host of foresight exercises by public and private organizations.

France recently began a complete overhaul of its research system and now has a Haut Conseil de la Science et de la Technologie (High Council of Science and Technology) that will be responsible for setting national research priorities. Prior to the reform, the FutuRIS group of Association nationale de recherche technique (France's National Association for Technical Research) also came up with a discussion paper on a sectoral definition of research and innovation priorities.

In 2004 the **United Kingdom**'s 2005-2008 science budget stood at approximately CDN$23 billion. It had two main priorities: public research and making better use of this research. Beyond the six functional priorities set out in the budget, two fields were acknowledged to be of vital importance, namely energy and clinical research.

Following the merger between Britain's Office of Science and Technology and the Department of Trade and Industry to create the Office of Science and Innovation, the newly formed Technology Strategy Board was tasked with setting new priorities to sustain innovation until 2008. The focus is on strategic sectors that will boost growth and productivity in a global economic context. A new Centre of Excellence in Science and Technology Horizon Scanning will also bolster the government-wide priority-setting process and the formulation of the science and technology strategy.

In November 2007 the British government asked its Council for Science and Technology to come up with a report setting out strategic fields for investment. Entitled "Strategic Decision-making for Technology Policy," the document put forward ten technologies that could be developed within five years and were likely to have an impact on society's well-being and the economy.

The United Kingdom has also carried on with its well-known Foresight UK program. Set up in 1994, the program seeks to set out future challenges and opportunities in certain strategic domains.

Over the years, **Germany** has adopted various and occasionally more social approaches that have recently paid greater heed to identifying priority technologies. In the field of innovation, the 2005 National Reform Program stresses four functional priorities while the R&D Direct Research Promotion thematic program funds public and private research projects in high technology fields. The areas that receive most funding are ICT, biotechnologies, medical technologies, production technologies (nanotechnology, microsystems, and optical technologies), the environment, energy, and transportation.

Germany's Futur foresight project (2001-2005) is one of the country's best-known priority-setting exercises. Other foresight exercises were piloted by the Innovation and Technology Analyses Department of the Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung).

Certain European countries stepped up R&D strategic planning efforts from the 1990s onward, which has led to solid and innovative priority-setting exercises.

Via the Austrian Council for Research and Technology Development (Rat für Forschung und Technologieentwicklung), **Austria** has made a number of changes to its R&D funding system since the 2000s. It has conducted priority-setting exercises that have identified functional and thematic priorities. From 1996 to 1998, an ambitious foresight exercise launched the country's priority-setting efforts.

The **Czech Republic**, which boasts both a national innovation policy and a national research and development policy, has a general system that puts great stock on targeted and applied research. The country's research priorities are officially set out in National Research Programs I and II. In order to support national research program preparation, since 2000 the government has backed national foresight exercises that help set thematic priorities outlined in national plans. A systematic and recurring foresight exercise to help define National Research Program III (2009-2014) priorities is underway.

Spain has had a priority-setting mechanism since the 1980s. Its systematic priority-setting exercises define thematic priorities enshrined in the country's National Plans for Scientific Research, Development, and Technological Innovation. More recently other, functional priorities were also included in the Spanish National Reform Program (2005-2010).

Scandinavian countries, particularly Finland and Denmark, have their own general approaches notable for their science and technology coordination efforts (and thus governance). Priorities are set both nationally and within various public organizations for research funding.

Finland's science, technology, and innovation policies always include functional and thematic priorities. The most recent strategy from Council for Science and Technology Policy, released in 2006, sets out a number of thematic priorities while emphasizing the need for centers of strategic excellence to earmark key fields for the country's development. The service sector is one field in which the Finnish government is planning to invest a lot of time and effort over the next few years.

For a number of years, Finnish Funding Agency for Technology and Innovation (Tekes) has developed technology programs whose strategic focus areas are identified using a specific priority-setting process repeated every three years. This priority-setting exercise can be used to determine three kinds of priority fields: promising fields, technology fields, and application fields. The VTT Technical Research Center of Finland (Valtion teknillinen tutkimuskeskus) also identifies its own priorities, notably with the help of foresight exercises and technology roadmaps. This research center's mission is to continuously foster specific skills and develop a knowledge base of the priority fields selected by the country and considered to be important for Finland.

Since 2005 the Finnish government has strengthened the foresight function of its strategic decision-making center. In addition to a government foresight network, the Finnish Fund for Innovation (SITRA) now also has its own national foresight network. Academy of Finland (Suomen Akatemia) and Tekes were also behind a priority-setting exercise known as FinnSight 2015, for which the final report was published in 2006.

Denmark's main strategies and policies tend not to contain specific thematic priorities, although they do suggest a number of ambitious functional priorities as defined mostly by Ministry of Science, Technology, and Innovation. Thematic priority-setting is chiefly the purview of various public R&D organizations, more particularly advisory bodies tasked with funding public research. To this end, the recent reform of the Danish advisory system has created two complementary advisory bodies. Independent research, which stems directly from researchers' interests and priorities, is the responsibility of the Danish Council for Independent Research. The Council is comprised of five advisory bodies that cover all traditional fields of research.

The advisory body tasked with setting thematic research priorities is the Danish Council for Strategic Research (DSF). Created in 2004, DSF's mandate is to fund research in selected fields that are priorities for the country. The Council must also encourage interaction between the public and private sectors and determine new research trends. It set out its action plan in a strategy published in September 2004 and entitled "Research That Counts."

In order to fulfill its mission, to date DSF has identified ten Innovation Accelerating Research Platforms. The initiative's main goal is to strengthen the correlation between society's strategic needs and government-funded strategic research fields. The platforms, which help accelerate innovation, draw on the very latest interdisciplinary and interinstitutional research.

The American Approach

According to David Cheney (2003), there is no central planning for R&D in the **United States**, with the Office of Science and Technology Policy acting as a coordinator rather than an administrator. Federal agencies such as the National Aeronautics and Space Administration (NASA), the Department of Defense, and the National Science Foundation each have their own missions and priority-setting processes.

Since the turn of the 21st century, however, the federal budget process has been largely responsible for setting the U.S. government's main priorities. Every year a memo produced by the Executive Office and the Office of Science and Technology Policy is sent to department heads and federal agencies. It sets out research and development priorities across the country by:

- suggesting ways to define priorities for various R&D programs;
- earmarking certain interdisciplinary fields of research for special investment within agency and departmental budgets; and
- reiterating certain R&D investment criteria.

Although the United States is renowned for having used and developed a number of foresight methods, recently it has not conducted any large-scale national priority-setting exercises to determine thematic priorities for research. As a rule, American foresight exercises–which help fuel general discussion of the country's science and technology development–are carried out by private organizations at the state or city level or in certain public organizations such as the Department of Defense. America's best-known federal priority-setting exercises are no doubt the Critical Technologies exercises conducted in the 1990s in conjunction with respected private firms such as the RAND Corporation.

The Asian Experience

Japan is known the world over for the numerous Delphi-type foresight exercises it has carried out since the 1970s that underpin its main research priorities. The eighth of such exercises was used to draw up the latest Science and Technology Basic Plan III. The plan, which contains a host of functional priorities, also proposes a number of technologies of importance to the country. Above and beyond these exercises, Japan's Ministry of the Economy, Trade, and Industry regularly produces technology roadmaps that set out development strategies for some 20 technologies associated with the priorities of the third National Plan.

Japan's science and technology budgets for four national thematic priorities rose from 38% in 2001 to 46% in 2005, demonstrating the strategic importance of scientific priorities for the country.

Priority-setting and foresight in **South Korea** is largely the preserve of the South Korean government. Its exercises were initially influenced by Japanese experiences such as Delphi, but have diversified over the years. The government-run Vision 2025 priority-setting exercise of 1999 is typical of a priority-setting exercise with a view to long-term R&D planning. It led to the implementation of the 21st Century Frontier Science Program, which implemented the functional and thematic priorities set in 1999.

South Korea also conducted Delphi-type foresight exercises in 1993, 1999, and 2003. Its Ministry of Research, Science, and Technology (MRST) subsequently integrated the results of the latest Delphi exercise into the 21 Future Technology Areas strategic plan. MRST also conducted a "Critical Technologies"-type exercise in 2002. Although MRST was responsible for the 2002 National Technology Roadmaps, other ministries have been put in charge of similar exercises.

The South Korean government's most recent priority-setting exercise dates back to 2006. The R&D Total Roadmap identified 90 technological priorities, 33 of which would be fast-tracked. This exercise significantly contributed to the development of the second Basic Plan of Science and Technology, which covers the period from 2008 to 2012. The impact of this priority-setting exercise will be huge: the government plans to increase R&D investment for certain priorities (i.e., biotechnologies, energy technologies, environmental technologies, and basic research), while other areas of technology development will see their budgets cut (machinery, manufacturing, I.T., and electronics).

Priority-setting in **China** is mainly a job for Ministry of Science and Technology (MOST). One of MOST's missions is to identify priority fields and formulate national R&D strategies, policies, and laws. Its methodological way of working is testament to a longstanding attachment to top-down approaches, and the decision-making process is highly centralized.

China set up a National Key R&D Technology Program in 1982. The program is used to determine which technologies will contribute to the technological and economic development of Chinese industries. In order to do this, MOST introduced a foresight process in the mid 1990s. The Selection of National Critical Technology exercise of 1995 helped develop the Ninth Five-Year Science and Technology Planning exercise. Another report–"Technology Foresight of Priority Industries in China"–was published in 1999.

Chinese Academy of Sciences (CAS) has been behind a number of foresight exercises carried out since the 1980s, and some of the Academy's experts helped draw up a methodological framework to pinpoint the country's critical technologies. In 2003 CAS began a foresight exercise–Technology Foresight Towards 2020 in China–that aimed to set technology development priorities for China. The document, published in 2006, brought about big changes in the country's decision-making process: China's education ministry recommended that all other ministries adopt the priority-setting approach advocated by Technology Foresight Towards 2020, and cities like Shanghai and Beijing referred to the document when conducting their own studies on the demand for new technologies.

Australia and New Zealand

Before 2000, **Australia** had a piecemeal approach to priority-setting, with the main ministries and agencies concerned developing their own priorities. Some of the country's priority-setting initiatives achieved worldwide recognition, including an exercise by the Commonwealth Scientific and Industrial Research Organization (CSIRO), which made its name developing priority criteria that went on to be adopted by several other countries in the 1990s and the following decade. In 1996 another initiative spearheaded by the Australian Science and Technology Council used foresight to explore possible avenues of scientific development while identifying priority fields of national interest.[95]

This piecemeal approach continued until 2001, when the Australian government published a major action plan for innovation entitled "Backing Australia's Ability." The action plan stressed the need for a nationwide approach to better target research, while emphasizing the fields in which Australia already had (or hoped to have) a competitive advantage. In May 2002 Ministry of Education, Science, and Training and the science minister announced the Australian government's intention to implement a vast national priority-setting operation across the government.

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[95] For more information see Matching Science and Technology to Future Needs 2010 at http://dest.gov.au/archive/Science/astec/future/findings/index.html.

In 2004 following extensive public consultations and acting on the advice of various experts, the Australian government put forward four main national priorities that still have a big impact today on strategic planning for the country's research and innovation stakeholders. As part of changes to Australia's national innovation system, the minister for innovation, industry, science, and research recently came up with a series of national innovation priorities to complement Australia's national research priorities.[96]

New Zealand's science and technology portfolio divides funding among four main functional priorities enshrined in the national budget. Each priority also has subpriorities of a more thematic nature that are reflected in both Ministry of Research, Science, and Technology (MoRST) programs and the strategic planning of the country's main research funding bodies.[97]

MoRST plays a key role in setting New Zealand's priorities. The Ministry is behind various foresight exercises and the production of technology roadmaps. In 2007 it installed a major monitoring system for emerging technologies and research fields.[98] Ministry initiatives are very often backed by consultations with stakeholders, and New Zealand always includes mention of its aboriginal peoples in its priorities.

The latest consultation dates back to summer 2006, when MoRST organized workshops to identify research fields and technologies likely to transform New Zealand's economy. Following the deliberations of scientists and government authorities, six Transformational Research, Science, and Technology Areas were selected and will receive substantial investment over the next few years.

OECD (2007) recently noted a growing desire on the part of New Zealand's government to implement national research priorities across the various ministries concerned by research and innovation, including the country's ministries for education, health, and economic development.

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[96] The national innovation priorities can be consulted in the following document: Australian Government (2008), *Venturous Australia. Building Strength in Innovation*, Cutler & Company Pty Ltd, http://www.innovation.gov.au/innovationreview/Documents/NIS-review-web1.pdf.

[97] These funding bodies are the Royal Society of New Zealand; the Foundation for Research, Science, and Technology; and the Health Research Council.

[98] For more information, visit the FutureWatch website at http://www.morst.govt.nz/current-work/futurewatch/.

Appendix 3

Priority Allocation (N) by Thematic Category and Field of Interest for the 21 Priority-Setting Exercises Studied for this Advisory Report[99]

Thematic Category	Field of Interest	N
Cutting-edge technologies and innovation	Information and communications technologies	49
	Materials and nanotechnologies	36
	Instrumentation, controls, machinery, and procedures	15
	Biotechnologies	14
	Unspecified	5
	Subtotal	**119**
Social and economic development	Macroeconomic problems	37
	Key sectors	14
	Education	7
	Management	3
	Subtotal	**61**
Health	Medical and bioinformatic technologies	39
	Public health and lifestyles	15
	Health system efficiency	5
	Unspecified	2
	Subtotal	**61**
Environmental protection and sustainable development	Natural environment preservation	12
	Industry	7
	Recycling, recovery, and decontamination	7
	Buildings	6
	Land development	5
	Unspecified	1
	Subtotal	**38**
Natural resources	Agriculture and agrifood	22
	Forests	5
	Water	4
	Mines and soil	3
	Unspecified	3
	Subtotal	**37**

(suite)

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[99] This table suggests a preliminary classification by thematic category and field for the results of priority-setting exercises consulted in preparing this advisory report. Further work on classification criteria would no doubt result in various changes to these priorities.

(suite)

Thematic Category	Field of Interest	N
Energy	Energy technologies	9
	Energy production, transmission, and consumption	9
	Nuclear powerplants	3
	Fossil fuels	4
	Unspecified	8
	Subtotal	**33**
Transportation	Fleet logistics, intermodality, and management	9
	Transportation network	7
	Maritime transportation	1
	Unspecified	4
	Subtotal	**21**
National security		9
Basic research		1
	Total	**380**

Appendix 4

Priority Allocation (N) by Field of Interest for the 21 Priority-Setting Exercises Studied for this Advisory Report[100]

Fields	N
Information and communication technologies (ICT)	49
Medical and bioinformatic technologies	39
Macroeconomic problems	37
Materials and nanotechnologies	36
Agriculture and agrifood	22
Public health and lifestyles	15
Instrumentation, controls, machinery, and procedures	15
Key sectors	14
Biotechnologies	14
Natural environment preservation	12
Energy technologies	9
Fleet logistics, intermodality, and management	9
Energy production, transmission, and consumption	9
Transportation network	7
Recycling, recovery, and decontamination	7
Industry	7
Education	7
Buildings	6
Land development	5
Health system efficiency	5
Forests	5
Combustibles fossiles	4
Water	4
Nuclear powerplants	3
Management	3
Mines and soil	3
Maritime transportation	1
Subtotal	347

(suite)

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[100] This table suggests a preliminary classification by thematic category and field for the results of priority-setting exercises consulted in preparing this advisory report. Further work on classification criteria would no doubt result in various changes to these priorities.

(suite)

Domaines		N
Unspecified	Energy	8
	Cutting-edge technologies and innovation	5
	Transportation	4
	Natural resources	3
	Health	2
	Environmental protection and sustainable development	1
	Subtotal	**23**
National security		9
Basic research		1
	Total	**380**

Appendix 5

Seminar on Priority-setting in Science and Technology: Best Approaches, Success Factors, and Impacts

When writing this advisory report, CST in tandem with the steering committee brought together international experts as well as research and innovation stakeholders from Québec and the rest of Canada to discuss priority-setting. The seminar was held in Montréal on June 2, 2008, and had three goals:

1) Foster debate among stakeholders interested in priority-setting.
2) Develop initial insights on possible approaches for Québec to explore.
3) Aid CST in its work on the report by identifying factors that contribute to success and maximize impact.

In the morning, four experts shared their knowledge and experience of priority-setting with 40-odd participants from Québec:

- Caroline Wagner, Researcher, Center for International Science & Technology Policy, George Washington University, United States.
- Arie Rip, Researcher, University of Twente, Netherlands.
- Robin Batterham, Chief scientist at Rio Tinto and Australia's former Chief scientist.
- Philippe Bourgeois, Director, Centre d'analyse régionale des mutations de l'économie et de l'emploi (Regional Analysis Center for Changes to the Economy and Employment) and project Coordinator for Technologies clés 2005 (Key Technologies 2005) and Technologies clés 2010 (Key Technologies 2010) in France.

The speakers addressed various aspects of priority-setting, including success factors, how to maximize impact, best practices, mistakes and problems to avoid.

The debate continued throughout the afternoon with a presentation from Michael Keenan, researcher at University of Manchester in the United Kingdom and newly appointed administrator at the OECD Science and Technology Policy Division. In light of the experiences presented in the first half of the seminar and drawing on his broad experience in the field, Michael Keenan discussed best practices in science and technology priority-setting based on lessons learned from these exercises.

Following a presentation by former CST secretary general Alain Bergeron on the context and experiences of priority-setting in Québec, discussions between participants and speakers addressed the province's unique context and how foreign experiences could be applied there.

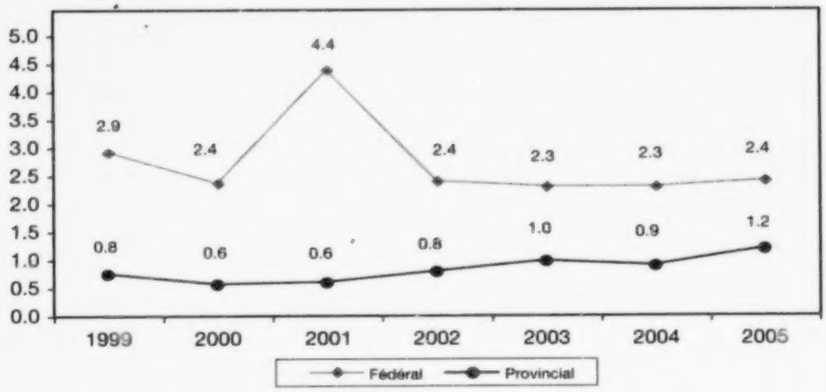
The discussions sought to answer questions about priority-setting experiences abroad and whether to apply them in whole or in part in Québec, features and issues that could play a part in setting out a Québec approach to priority-setting in research and innovation, and success factors for optimal priority-setting approaches. These factors are:

- Which process is used and how it is planned (method, targeted results, and the role of foresight), as well as who participates (political, scientific, and industrial communities, the general public, etc.).
- The balancing of Québec's priorities with those of the rest of Canada and the international community.
- The communication, acceptance, and use of the results by the relevant authorities.
- The maximization of impacts (on policy, budgeting processes, science and technology development, society, etc.).

Speakers' presentations (English and French) and the seminar proceedings (in French) are available at http://www.cst.gouv.qc.ca/ .

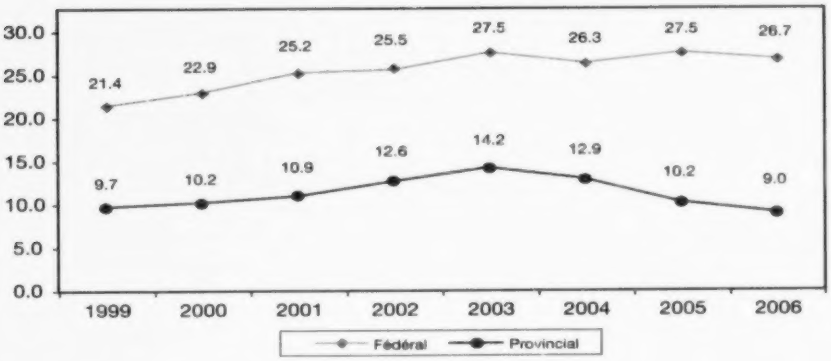
Appendix 6
Research Funding Sources in Québec (other than GERD): Federal vs. Provincial

Figure 5 – BERD in Québec 1999-2005 (as a percentage)



Source: Databank of Official Statistics on Québec (DBOS), Government of Québec, 2008

Figure 6 – HERD in Québec 1999-2005 (as a percentage)



Source: Databank of Official Statistics on Québec (DBOS), Government of Québec, 2008

Appendix 7
Members of the Steering Committee

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Members
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Director General
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Executive Vice-President
Social Sciences and Humanities Research Council of Canada

Ms. Sylvie Dillard
Director
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Deputy Minister Office
Ministère du Développement économique, de l'Innovation et de l'Exportation

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Mr. Moktar Lamari
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Conseil de la science et de la technologie
Mr. Alain Bergeron
Secretary General (until may 2008)

Ms. Lise Santerre
Secretary General a.i.

Coordination of the steering committee
Ms. Geneviève Drolet
Foresight and priority-setting advisor
Conseil de la science et de la technologie

Appendix 8
Conseil de la science et de la technologie's Members

President
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Members
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